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ABSTRACT

This publication is the third in a series of monographs reporting the results of studies made by personnel in the Science Education Center of the University of Texas at Austin. Several of the studies in this issue were attempts at identifying broad areas of teacher behavior affecting student outcomes, which, once identified, could be the basis for further cause-and-effect research. Inservice training using modeling strategies was found to bring about improvement of student and teacher behavior by two authors. Two other studies established correlations between teacher behavior and the attitudes of students, students' critical thinking skills, and students' views of the tentativeness of science. One investigator reports an inverse relationship was found between the frequency of a teacher's use of student names and the frequency of non-productive silence and confusion in the classroom. Other studies presented may be of interest to a broad spectrum of science educators. Fifteen papers are presented. (Author/EB)

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RESEARCH AND CURRICULUM DEVELOPMENT IN SCIENCE EDUCATION

3. SCIENCE TEACHER BEHAVIORS AND STUDENT AFFECTIVE AND COGNITIVE LEARNING

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FOREWORD

This research monograph is the third in a series of monographs reporting the results of studies conducted by personnel in the Science Education Center, The University of Texas at Austin.

Currently there is a great deal of research and development in the area of Competency-Based Teacher Education. Several of the studies reported in this monograph were attempts at identifying broad areas of teacher behavior effecting student outcomes, which once identified, could be the basis for further cause-and-effect research. The results of these studies suggest several promising areas for such research.

Spradlin found that teacher behavior in the classroom could be modified by inservice training using modeling strategies. Montague found that the same modeling strategies for inservice training could result in an improvement of student attitudes in the classes of teachers so trained. Hillis and Jingozian established correlations between teacher behavior and the attitudes of students, students' critical thinking skills, and students' views of the tentativeness of science. Lamb found an inverse relationship between the frequency of a teacher's use of student names and the frequency of nonproductive silence and confusion in the classroom. These studies in total have therefore indicated that relationships exist between teacher behavior and student outcomes, and further, that teacher behavior can be modified. Areas for cause-and-effect research therefore have been delineated. The results produced from this cause-and-effect research could have important implications for competency-based teacher education in science.

Other studies presented in this monograph may be of interest to a broad spectrum of science educators. Certainly the instruments described in some of these reports will be useful in several areas of on-going research.

A number of people contributed to the development of this publication. In particular, appreciation is extended to Dr. Addison E. Lee, Dr. James P. Barufaldi, Dr. John P. Huntsberger, Dr. Rolland B. Bartholomew, and Dr. Lowell J. Bethel who critiqued the reports included in this monograph; Mrs. Joan Vance and Mrs. Kris Cervenka, who were responsible for the typing and preparation of the manuscripts for publication; and Mrs. Bonner Schwab, who coordinated the project.

EARL J. MONTAGUE
Austin, Texas
March, 1975

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A STUDY OF THE RELATIONSHIPS BETWEEN CERTAIN TEACHER PRACTICES AND STUDENT ATTITUDES IN THE SECONDARY SCIENCE CLASSROOM

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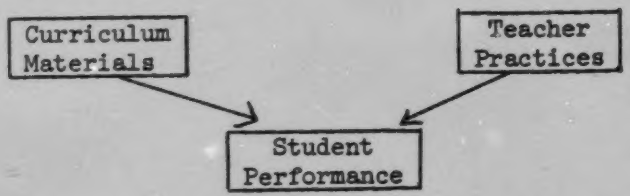
INTRODUCTION

Prior to the major curriculum development projects of the 1960's, science curricula were largely content-oriented. During the 1960's content-process science programs were developed. The new programs introduced an emphasis on the attainment of affective goals. The "inquiry method" espoused by Schwab (1962) and the "new humanism" in science as advocated by Bronowski (1968) are two examples. This trend requires an emphasis on positive attitude development toward all areas that encompass the scientific endeavor as well as achievement of cognitive competence in science.

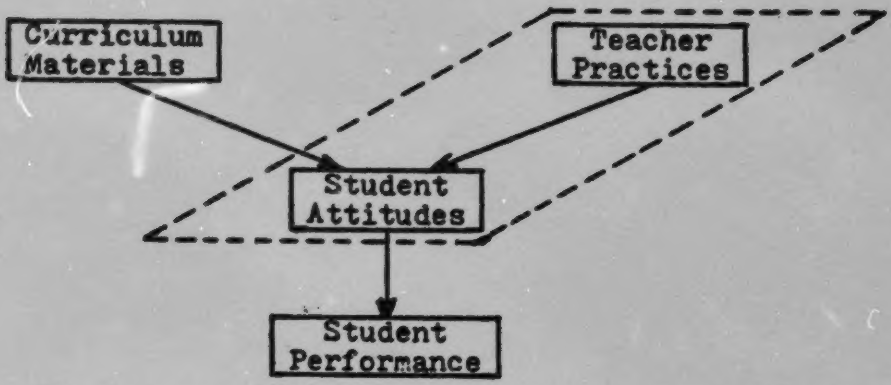
It is maintained that a student with a particular attitude portrays a bias to function in ways parallel with his attitude. Mager (1968) notes that attitudes can be influenced and that the teacher is one of the influencing factors. The new curricula recognize the potential of the affective domain in science education, that the best teacher practices will result in learning by all the students and that student attitudes toward science-oriented objects are, in many instances, comparable in importance to cognitive learnings.

THE PROBLEM

Most educators generally agree that it is a combination of curriculum materials and teacher practices which ultimately determine a student's performance in the classroom. Flanders (1963), Hurd (1964), and others have suggested that the practices of the teacher are of comparable importance with relation to the content of any curriculum project. Kochendorfer (1966) illustrates these concepts by means of the following diagram:



However, it is felt that the attitude of a student toward a particular subject is the vital final link toward his performance in that subject. Many factors are involved in whatever attitudes a student may possess, such as his background, interests, needs and abilities. However, the immediate environment of the teacher-student relationship, together with the assumption that teachers' practices are to some extent determined by the available curriculum materials, may be illustrated by the following diagram:



The need to evaluate the relationship between teacher practices and student attitudes becomes evident. Perhaps certain teacher practices, exclusive of teachers' knowledge of subject matter, have a significant relation to the attitudes of students in the secondary science classroom. The purpose of this study was to identify possible relationships between teacher inquiry practices and the attitudes of students.

INSTRUMENTS USED

The semantic differential, developed by Osgood (1957) is an instrument capable of observing and measuring the perception of an individual toward various concepts. This scale was used to identify the evaluative, potency and activity dimensions of students' attitudes toward four attitude objects. The attitude objects examined were: (1) Science, (2) Science Class, (3) Science Laboratory and (4) Science Teacher.

The Science Classroom Activities Checklist (SCAC) was originally developed by Kochendorfer (1966) as the Biology Classroom Activities Check list (BCAC). Seven specific teacher practices evolved from a list of fifty-three items on the BCAC, twenty-six being described as positive practices and twenty-seven as negative practices. Kochendorfer determined a judgemental reliability coefficient of .96 and a validity correlation of .84 for the BCAC. These values tend to establish a high degree of reliability and a high degree of agreement concerning the content validity for the items.

The seven teachers' practices examined by Kochendorfer were:

1. The role of the teacher
2. Student participation
3. Use of curriculum materials
4. Tests
5. Pre-laboratory
6. Laboratory
7. Post-laboratory

The BCAC was devised as a checklist to determine how well students perceived their teachers' practices in the secondary science biology classroom. Kochendorfer chose to use a true-false response method. The questionnaire was both simple to administer and easy to score.

The BCAC has been revised slightly to be applicable to all areas of science. An occasional word or phrase has been replaced by another word or phrase. One additional item has been added to the original fifty-three items. Very few statements have been replaced by other statements, and specific references to "biology" have been replaced by the word "science."

The seven teacher practices which constitute the subscales on the SCAC are:

Teacher practice A—Role of the Teacher. Low scores describe an authoritarian teacher. Straight lectures are featured, the text is infallible and science has all the answers. High scores identify practices which permit freedom of discussion and analyses of text material which will permit students to draw their own conclusions.

Teacher practice B—Student Participation. Low scores imply that learning is accomplished by writing study questions, watching teacher demonstrations and memorizing teacher provided facts. High scores represent student involvement, discussing problems of science and scientists, and carrying out their own demonstrations.

Teacher practice C—Use of Curriculum Materials. Low scores indicate a teacher who presents the text as a source of facts to memorize, a maze of word list definitions and something to be outlined. High scores reveal text use as a source of problems and further class discussions. The text is subjected to careful analysis while students investigate original works of scientists.

Teacher practice D—Tests. Low scores portray practices such as the writing of definitions of terms, the labeling of drawings and the regurgitation of rote memory work. High scores reflect that tests include a balance between laboratory exercises and class discussion which lead the student to investigate new problems and to draw independent conclusions.

Teacher practice E—Pre-Laboratory. Low scores indicate step-by-step teacher instructions, laboratory work unrelated to class discussions, and predetermined conclusions. High scores indicate that the laboratory is used as a place to investigate problems when they arise in class discussions and reflect well-organized preparation.

Teacher practice F—Laboratory. Low scores indicate a cookbook laboratory situation and/or little individual experimentation while the teacher is engaged in other work. High scores indicate some originality and comparison of collected data among the students. The teacher is actively involved in the laboratory situation.

Teacher practice G—Post-Laboratory. Low scores denote little follow-up of laboratory exercises. The laboratory notebook, its neatness and copied procedure, purpose and materials used, is the principal and desired end. High scores suggest much activity and student involvement following the laboratory exercise. Results are discussed among the students under the leadership of the teacher, graphs of data are constructed and all conclusions are analyzed.

DESIGN OF THE STUDY

Eight suburban school systems in the Greater Boston (Mass.) area were selected from among twenty school systems invited to participate in this study. Nine secondary school science classes within each school system were used; namely, three classes according to ability levels of students, identified as non-college preparatory, college preparatory and accelerated students; and in each of the three major science disciplines, biology, chemistry, and physics. An effective population of 1,358 students comprised the total of seventy-two classes.

The nature of the study suggested a series of factorial designs for statistical analyses. Interaction effects could also be determined by the factorial design method. All mean scores for both subjects and levels, as well as for all subject by level combinations, were computed using the Boston University IBM 360, Model 50 Computer. All analyses were personally performed on a computer terminal utilizing an interactive statistical package.

There were altogether nineteen variables involved. The teacher practices accounted for seven of these, while the remaining twelve were accounted for by the evaluative, potency and activity dimensional factors toward the four attitude objects. Each variable was subjected to a three by three analysis of variance; namely, three subject factors and three placement levels.

The .05 level was chosen as the level of significance. All significant results were subjected to the Newman-Keuls procedure as a post-hoc procedure to examine more closely the factors contributing to the significance.

The factorial analyses exposed certain significant differences in both teacher practice mean scores and student attitude measurements as separate entities. The Pearson Product Moment Correlation (r) was then computed for 756 correlations to determine significant relationships between the students' perceptions of seven teacher practices and the students' attitudes in the three placement levels of the three science areas as measured by the evaluative, potency, and activity factors of the Osgood Semantic Differential. All correlations were computed by using the individual raw scores of all the students.

NULL HYPOTHESES

The primary purpose of this study was to identify relationships between student perceptions of seven teacher practices and student attitudes toward four attitude objects. However, the results could be meaningless if the teacher practices and the student attitudes were not individually examined. Guttman (1944) stated that while correlations between universes may be of interest, each universe should be defined and observed in its own right.

Therefore, there were three distinct hypotheses composed of a number of subhypotheses:

H_1: There are no differences in the mean scores of student perceptions of teacher practices A-G among biology, chemistry, and physics students.

There are no differences in the mean scores of student perceptions of teacher practices A-G among non-college preparatory, college preparatory and accelerated students.

There is no interaction in the mean scores of student perceptions of teacher practices A-G between subjects and levels.

H_2: There are no differences in the students' attitude mean scores (toward each of the four attitude objects) among biology, chemistry, and physics students.

There are no differences in the students' attitude mean scores (toward each of the four attitude objects) among non-college preparatory, college preparatory, and accelerated students.

There is no interaction in the students' attitude mean scores between subjects and levels.

H_3: There is no relationship between teachers' practices A-G and (science) students' perceptions of (attitude objects) as measured by the evaluative, potency and activity dimensions of the semantic differential.

RESULTS

It can be seen in Table 1 that significant differences exist between the means of students' perceptions of teacher practices B, C, and D and the science subjects studied. Chemistry students perceived their classroom participation as less inquiry oriented than did biology and physics students. Physics students perceived the curriculum materials being used as more inquiry oriented than did the biology or chemistry students. Biology students perceived their tests as being less inquiry oriented than did the chemistry or physics students. There were no significant differences between students in different subjects with regard to the degree of inquiry in the classroom as exhibited by the role of the teacher, the nature of the pre-laboratory discussions, the nature of the laboratory activities, or the nature of the post-laboratory discussions.

TABLE 1

Means for all Teacher Practice Scores for all Biology, Chemistry and Physics Students

Subject	Teacher Practices						
	A	B^{**}	C^{**}	D^{**}	E	F	G
Biology	28.41	20.86	21.31	17.94	25.13	28.05	24.69
Chemistry	28.29	19.41	21.97	20.73	25.75	28.65	24.60
Physics	27.39	20.40	22.66	20.41	25.95	28.50	25.22

$^{**}p < .01$

When the students' perceptions of teacher behavior were analyzed with respect to the levels of placement (See Table 2) several significant differences are evident. Those students enrolled in college preparatory courses perceived student participation and the curriculum materials being used as being less inquiry oriented than did those students enrolled in non-college oriented courses or in courses for the accelerated student. On the other hand, those students enrolled in accelerated courses perceived their tests, laboratory activities, and post-laboratory discussions as being more inquiry oriented than did the students in non-college or college preparatory courses.

TABLE 2

Means for all Teacher Practice Scores for all Levels of Placement

Level	Teacher Practices						
	A	B**	C**	D**	E	F**	G**
Non-College	27.65	21.02	22.39	18.78	25.82	27.32	24.42
College Prep.	27.97	19.51	21.01	19.42	25.40	28.35	24.36
Accelerated	28.46	20.21	22.60	20.88	25.61	29.55	25.80

$^{**}p < .01$

The fact that only one subject by level interaction was significant (See Table 3) is in accord with the theory of random sampling and substantiates the randomness of the sample used.

TABLE 3

Mean Scores for All Teacher Practices Subjects (S) by Levels (L)

	Teacher Practices						
Biology	A	B	C*	D	E	F	G
Non-college	27.29	21.50	22.29	18.13	25.71	27.20	24.92
College Prep.	28.43	20.14	19.22	17.42	24.63	27.58	23.50
Accelerated	29.52	20.98	22.57	18.32	25.08	29.41	25.73
Chemistry							
Non-college	27.96	19.48	21.52	18.81	25.51	27.38	23.26
College Prep.	28.30	18.95	21.95	20.68	25.65	28.80	24.14
Accelerated	28.60	19.86	22.42	22.65	26.11	29.71	26.42
Physics							
Non-college	27.73	21.82	23.17	19.35	26.16	27.39	24.90
College Prep.	27.12	19.42	21.93	20.24	25.97	28.70	25.52
Accelerated	27.28	19.79	22.80	21.74	25.68	29.54	25.30

$^{*}p < .05$

TABLE 4

Evaluative (E), Potency (P) and Activity (A) Dimension Mean Scores Toward Attitude Objects by Subjects and Levels

	Science			Science Class			Science Lab			Science Teacher		
Subject	E	P**	A	E	P	A	E	P	A	E	P	A
Bio	20.43	18.07	18.98	20.29	17.17	19.17	19.44	16.81	18.44	21.91	16.74	20.50
Chem	20.66	18.79	19.05	20.41	17.67	18.74	19.96	17.15	18.87	22.42	17.43	20.13
Phys	21.21	19.13	19.16	19.73	17.78	18.35	19.08	16.80	18.42	21.13	16.76	19.13
Level	E**	P**	A**	E*	P*	A**	E	P*	A**	E	P	A
N-C	19.82	17.39	18.29	19.47	16.75	18.22	18.91	16.35	17.87	21.69	16.70	19.44
C-P	20.36	18.85	18.70	19.86	17.84	18.28	19.58	16.99	18.64	21.66	16.79	19.70
Acc	22.19	19.78	20.26	21.11	18.03	19.79	19.96	17.42	19.23	22.07	17.43	20.33

*$p < .05$
**$p < .01$

Table 4 summarizes the findings with respect to Hypothesis 2. The students enrolled in biology perceived science as being less awesome than did students in chemistry or physics. There were no other significant differences in students' attitudes toward science, the science class, the science laboratory, or the science teacher between students enrolled in biology, chemistry, or physics.

Students enrolled in accelerated classes perceived science and their science class as being more valuable or worthwhile than did students in non-college or college preparatory classes. The accelerated students also perceived science, their science class, and science laboratory as being more potent and active than did other students.

Hypothesis 3 which relates to the relationships between the degree to which teacher practices are inquiry oriented and the attitudes of students is central to the study. A more detailed analysis of the data may be found in the original report of the research (Jingozian, 1973). A total of 756 correlations were calculated, and 312 found to be significant at the 0.05 level. A summary of the number of significant correlations is provided in Table 5.

TABLE 5

Number of Significant Correlations for Each Teacher Practice in Order of Rank

Teacher Practice	$p < .05$	$p < .01$	Total
F (Laboratory)	14	40	54
G (Post-laboratory)	16	38	54
A (Role of the Teacher)	18	34	52
B (Student Participation)	24	23	47
C (Use of Curriculum Materials)	10	32	42
E (Pre-laboratory)	17	22	39
D (Tests)	11	13	24

It can be seen from the data that there is a substantial number of relationships between teacher practices and the attitudes of students. The more inquiry in nature the teacher practices, the more favorable are the students' attitudes in approximately 41% of the categories tested.

A further breakdown of the distribution of correlations is given in Table 6. It can be seen that the largest number of relationships exist for physics students and those students in accelerated classes. Students' attitudes toward the science teacher seem to be somewhat more related to teacher practices than do students' attitudes toward science, science class, and science laboratory.

CONCLUSIONS

The primary purpose of this study (Hypothesis 3) was to identify certain relationships between students' perceptions of their secondary school science teachers' practices and the same students' attitudes toward Science, Science Class, Science Laboratory, and Science Teacher. In order to accomplish this purpose and to establish the validity of correlation coefficients which identified these re-

TABLE 6

Number of Computed Significant Correlations for the Attitude Objects Subdivided by the Evaluative, Potency and Activity Dimensions of the Semantic Differential for all Science Students According to Subjects and Placement Levels

	Science			Sci Class			Sci Lab			Sci Teacher			
	E	P	A	E	P	A	E	P	A	E	P	A	Totals
Subjects													
Biology	14	2	11	13	3	10	8	3	6	12	5	10	97
Chemistry	3	1	4	5	2	15	4	4	8	11	3	11	71
Physics	13	5	11	15	5	14	15	8	13	17	11	17	144
Totals	30	8	26	33	10	39	27	15	27	40	19	38	312
Levels													
Non-college	9	1	7	7	12	14	8	3	8	9	5	8	91
College Prep.	9	5	8	3	6	1	10	6	15	18	9	17	107
Accelerated	12	2	11	7	15	17	9	6	4	13	5	13	114
Totals	30	8	26	17	33	32	27	15	27	40	19	38	312

lationships, it was deemed necessary to first compare differences in mean scores for both students' perceptions of teacher practices (Hypothesis 1) and students' attitudes toward the attitude objects (Hypothesis 2) individually.

The conclusions are submitted in light of the three hypotheses of the study.

Hypothesis 1: First, the study was designed to analyze teacher practices by subject areas and placement levels. Examination of students' perceptions of their teachers' practices revealed no definite trends by subject areas. By placement levels, accelerated students perceived their teachers' practices as being more up-to-date than college preparatory students. Non-college preparatory students perceived their teachers' practices as the most strict, authoritative and traditional. College preparatory biology students' perceptions of their teachers' practices with regard to "tests" were very different from any other subject by level combination.

Hypothesis 2: Second, the study was designed to observe differences in students' attitudes toward the four attitude objects, Science, Science Class, Science Laboratory and Science Teacher. There was no definite trend in student attitudes by subject areas. By placement levels, accelerated students displayed the most favorable attitudes toward the four attitude objects, followed successively by the attitudes of college preparatory and non-college preparatory students.

Hypothesis 3: The previous conclusions were based upon the results obtained by defining and comparing teacher practices and student attitudes. However, the final conclusions pertain to the primary purpose of the study, which was to analyze the relationships between teacher practices and student attitudes.

Approximately 41.27 percent of the 756 correlations were found to be significant at the .05 level. Nearly half of these (144) were attributed to physics students, nearly one-third to biology students (97) and nearly one-fourth (71) to chemistry students.

Three general conclusions are submitted for Hypothesis 3:

1. Physics students' attitudes are more closely related to their teachers' practices than the attitudes of biology or chemistry students.

2. Accelerated and college preparatory students' attitudes are more closely related to their teachers' practices than the attitudes of non-college preparatory students.

3. The attitudes of all placement levels of science students toward their science teachers are more closely related to the practices of the teacher than are the students' attitudes toward science, science laboratory or science class.

Finally, the totality of findings afford sufficient evidence to suggest that the more the teachers' practices reflected the philosophy promoted in the new science curricula, the more favorable were the students' attitudes.

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SUMMER INSTITUTES FOR SCIENCE TEACHERS AND THEIR INFLUENCE IN THE AFFECTIVE DOMAIN

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INTRODUCTION

The ultimate criterion of a teacher's effectiveness is usually considered to be his effect on his pupils' achievement of some educational goal defined in terms of desired pupil behavior, abilities, habits, or attitudes (Gage, 1963, p. 116). For the purpose of this study one aspect of effectiveness of a teacher is measured by his classroom behavior and the attitudes his students develop toward the world of science. The classroom behavior of a teacher is an integral part of student attitude formation. Any change in the way in which a teacher perceives himself in his role as a teacher or the subject he teaches will reflect itself in his classroom behavior and thereby in the perceptions of his students.

The purpose of this study is to determine whether a teacher's involvement in a Summer Institute Program (SI) designed to increase his content competencies will alter his perception of self and subject, and subsequently alter his students' view of science and education as a whole.

THE SAMPLE

The sample for this study was divided into two groups: Group I was composed of 48 teachers selected for participation in the Summer Institute, 1971, at The University of Texas at Austin and 1,332 of their students; Group II contained 40 teachers involved in the Summer Institute, 1972, and 1,029 of their students. At the close of the first year of teaching following the institute, 32 Group I teachers and 30 in Group II responded to instruments prepared by the author and submitted to the teachers. Of the original sample, fourteen remained in school working toward advanced degrees, four no longer taught science, two suffered ill health, and six did not reply. At the time of the Group I second-year follow-up study, 26 teachers completed the instruments. Thus, sample numbers and scores for the Group I teachers were different between the first and second year study in the results which are reported later.

THE INSTRUMENTS

The *Student Semantic Differential* (SDS) contained 12 pairs of words selected to discover the Evaluation (Ev.), Potency (Po.), and Activity (Act.) factors described by Osgood (1957). The concepts, or protocols, to be rated were: Science Class, Science Laboratory, Science Teachers, and School. The participant's score was the class mean score of his students for each factor.

The *Teacher Semantic Differential* (TSD) contained nine protocols grouped into four categories descriptive of attitudes toward: Institutes, School Situations Over Which Teachers Have Little Control, Teaching as a Job, and Self as a

Science Teacher. The mean scores for each category were recorded as the participant's score.

The *Annual Self-Inventory for Science Teachers* (ASIST) was divided into seven sections containing statements that gave operational meaning to the general characteristics of the professional science teachers as defined by NSTA (1970). Mean scores were recorded for statements in each section and for the total score for each participant.

The *Teacher Concern Statement* (TCS) (Fuller, 1970) was a listing of the things about teaching that concerned the person. These were scored from Non-teaching concerns at Level 0 to Student-centered concerns at Level 6. The mean level of all concerns listed was the participant's TCS score.

TESTING

All four measures were taken in April of the teaching year prior to the institute, the first year of teaching following the institute, and, for the 1971 Summer Institute teachers, the second year following the institute. The TSD and TCS were administered at the close of both institutes.

Each participant selected a "typical" class for inclusion in the study and was asked to use a comparable class for the post-treatment measures; however, the investigator had no control over the students selected.

The research design used in this study is identified by Campbell and Stanley (1970) as one-group-Pretest-Posttest. The .05 level of significance was chosen to test the hypotheses formed for acceptance.

RESULTS

Null hypotheses were formed regarding change in student attitudes following their teacher's involvement in a SI retraining program. Data for Groups I and II were tested for change (Table 1).

Examination of Table 1 indicates that the students tested differed in their attitudes toward the world of science before and after their teacher's involvement in the SI in the following ways:

Students of Group II teachers felt their science class was more powerful ($p = .0049$); the science laboratory was more worthwhile ($p = .0150$), more powerful ($p = .0031$), and they felt more actively involved with it ($p = .0172$); the science teacher was perceived to be stronger ($p = .0130$), and they felt themselves more actively involved with school ($p = .0499$).

Data from teachers involved in the Group I follow-up study were compared and the results are given in Table 2. The data revealed that the students of teachers in Group I found their science laboratory to be more worthwhile and valuable by the close of the second post-institute year of teaching than had students of these teachers before their institute involvement ($p = .013$).

Null hypotheses were formed regarding change in teacher attitudes following institute involvement. Data for both groups were compared between Trials 1 and 2 and Trials 1 and 3, results are given on Table 3.

This table reveals that there was a post-institute drop in certain aspects of teacher attitudes that were partially re-established during the following year. The following changes were noted:

> Teachers regarded their institute experience as less valuable (Group I p = .010, Group II p = .001) and less powerful (Group I p = .051, Group II p = .001), and felt less actively involved (Group II p = .001) immediately after the institute. A year later they viewed it as more worthwhile (Group I p = .015) and their involvement with it as more active (Group I p = .004) than they had originally anticipated.
>
> Teachers regarded the school conditions over which they had little control as less important (Group I p = .031, Group II p = .001) and less powerful (Group II p = .009) to their success in teaching after their institute experience.

TABLE 1

Change in Student Attitudes Through Two Trials (SSD)
(one-group-two-trials analysis of variance)

Range Protocol Probability	0–28	Factor	Trial 1 Group	Trial 2 Group Mean	Groups by Trials Group Mean	F Ratio
Science Class	Ev.	I	20.2341	20.6752	.305	.5893
		II	19.6390	20.3148	2.658	.1106
	Po.	I	18.5712	17.7777	3.266	.0720
		II	16.8467	18.0887	9.438	.0049**
	Act.	I	17.9005	18.4032	.884	.3531
		II	17.8344	18.4616	3.284	.0773
Science Laboratory	Ev.	I	20.3882	20.5615	.003	.9558
		II	19.8012	21.1516	6.606	.0150**
	Po.	I	17.0818	17.3032	.282	.6035
		II	16.8483	17.8590	10.737	.0031**
	Act.	I	18.4325	18.7080	.037	.8393
		II	18.0141	18.9387	6.299	.0172**
Science Teacher	Ev.	I	22.5987	22.5787	.000	.9943
		II	21.2393	21.8851	1.363	.2517
	Po.	I	18.5745	18.2536	.286	.6025
		II	17.5886	18.6841	6.939	.0130**
	Act.	I	19.5789	19.5689	.001	.9778
		II	19.0878	19.6381	1.779	.1903
School	Ev.	I	18.2345	18.6589	.474	.5005
		II	17.5632	18.2004	.996	.3278
	Po.	I	19.1476	19.5745	.790	.3813
		II	19.0030	19.3685	.451	.5142
	Act.	I	17.9896	18.2771	.451	.5142
		II	17.4732	18.3939	3.880	.0499*

*sig. .05
**sig. .01

Group I (SI '71) N=32
Group II (SI '72) N=30

TABLE 2

Group I Change in Student Attitudes Through Three Trials (SSD)
(one-group-three trials-analysis of variance)

Protocol	Factor	Trial 1 Group Mean	Trial 2 Group Mean	Trial 3 Group Mean	F Ratio	Probability
Science Class	Ev.	20.7501	20.8681	21.5535	.968	.3887
	Po.	18.6690	17.9102	18.1918	.995	.3788
	Act.	18.1418	18.6293	18.8544	1.270	.2893
Science Laboratory	Ev.	20.6655	20.2466	22.2265	4.714	.0132*
	Po.	17.2056	17.5167	17.9621	2.077	.1330
	Act.	18.7035	18.5710	19.3852	2.044	.1383
Science Teacher	Ev.	23.1580	22.7916	23.0994	.205	.8171
	Po.	18.9626	18.3621	18.9021	1.399	.2554
	Act.	19.8554	19.5716	19.9487	.406	.6748
School	Ev.	18.3361	18.7795	19.4462	.876	.4355
	Po.	19.1618	19.7306	19.9431	1.673	.1925
	Act.	18.1789	18.3345	18.9180	1.209	.3069

*sig. .05 Group I (2 Year Study) N=26

> Teaching as a job was felt to be less worthwhile (Group II $p = .001$), less powerful (Group II $p = .001$) and less actively involving (Group II $p = .001$) after the institute experience.
>
> Teachers lost some sense of worthiness (Group I $p = .007$, Group II $p = .001$), lost power (Group I $p = .031$, Group II $p = .001$) in themselves as science teachers and perceived themselves as less actively involved in teaching (Group II $p = .001$) at the close of the institute, yet one year later all returned to their pre-institute attitudes toward themselves as science teachers.

Data for the Group I teachers in the second year follow-up study (Table 4) reveals that by the close of the second year after the institute, the teachers viewed their involvement in the institute as more valuable ($p = .008$), less awesome ($p = .010$), and themselves as more actively involved ($p = .020$) than they perceived before the institute.

Null hypotheses were formed regarding change in participants' self-evaluation of themselves as professional science teachers. Data for both groups were compared between Trials 1 and 2 (Table 5).

This table reveals that at the close of the first year of teaching following the institute, teachers' professional perceptions of themselves had changed by improvement in the following ways:

> They felt they were better educated in science and the liberal arts (Group I $p = .0001$, Group II $p = .002$), had a more functional philosophy of education and more technical skills of teaching (Group II $p = .046$), had continued to grow in knowledge and skills (Group I $p = .006$, Group II $p = .003$), had insisted more on a sound educational environment in which to work (Group I $p = .001$, Group II $p = .001$), had done more to maintain

their professional status (Group I p = .021, Group II p = .047), had contributed more to improvement of science teaching (Group I p = .003, Group II p = .032), had taken a more vital interest in the quality of future science teachers (Group I p = .004, Group II p = .032), and in general beheld themselves as more professional persons (Group I p = .0005, Group II p = .0007).

The teachers in the second year study (Group III, Table 5) at the close of the second year of teaching following the institute felt their perceptions of themselves as professional persons had further improved in that they were better

TABLE 3

Change in Teacher Attitudes Through Two Trials (TSD)

(one-group-two-trials analysis of variance)

Protocol	Group	Trial 1 Group Mean	Trial 2 Group Mean	Trial 3 Group Mean	Trial 1-2 F Ratio	Trial 1-3 F Ratio
Institute (Range 4–28)						
Ev.	I	24.6562	23.7187	25.8750	7.512••	5.906••
	II	25.6552	16.7586	23.7241	271.531•••	3.535
Po.	I	20.5937	18.8750	20.4375	4.307•	3.833•
	II	21.0000	16.2759	20.0345	50.089•••	.673
Act.	I	22.3750	21.5625	22.9375	4.418•	4.695•
	II	22.4138	17.5172	23.6552	36.824•••	.458
School Situation (Range 12–84)						
Ev.	I	54.5313	51.6562	54.4687	5.626•	.098
	II	57.9655	48.0347	54.9310	15.521•••	.977
Po.	I	53.6875	54.6562	55.4375	.252	1.580
	II	57.1378	53.0698	60.9310	6.923••	.708
Act.	I	51.6562	52.5625	53.1250	.603	.671
	II	56.2414	51.9655	58.8966	3.483	1.138
Teaching as a Job (Range 12–84)						
Ev.	I	73.1250	72.5312	73.4687	.373	.010
	II	70.8966	50.5862	70.6552	145.363•••	.007
Po.	I	65.9687	64.3437	65.2812	3.978	.746
	II	61.7241	52.5517	68.0698	21.509•••	1.522
Act.	I	69.2800	68.1600	70.0400	.413	.177
	II	66.7931	51.5517	70.3103	50.471•••	2.813
Self as a Science Teacher (Range 8–56)						
Ev.	I	46.3750	43.5213	46.2812	7.653••	5.008•
	II	46.5862	32.9655	45.3448	167.601•••	.393
Po.	I	42.0625	40.0312	42.1562	2.994•	3.877•
	II	42.2414	36.4828	43.1034	20.503•••	.246
Act.	I	42.8750	41.5000	42.8750	.703	.001
	II	43.1724	33.5172	47.3793	68.781•••	2.381

• sig. .05
•• sig. .01
••• sig. .001

Group I (SI '71) N=32
Group II (SI '72) N=40

educated in science and the liberal arts (p = .0001), had a more functional philosophy of education and had more technical skills of teaching (p = .0058), had continued to grow in knowledge and skills (p = .0010), showed a greater interest in a sound educational environment in which to work (p = .0016), had had contributed more to the improvement of science teaching (p = .0013), had taken a more vital interest in the quality of future science teachers (p = .0010), in all, they rated themselves as more professional persons (p = .0007).

Null hypotheses were formed regarding change in the maturity of teachers' concerns about teaching. Data for both groups were compared between Trials (Table 6).

At the close of the first year of teaching following the institute, the level of the teachers' concerns about teaching had changed in that:

> The mean level of the teachers' concerns was more student-oriented (Group I p = .049) and the level of their most frequently listed concern was more mature (Group I p = .008).

At the close of the second year of teaching following the institute, teachers in the Group I follow-up study had changed as follows:

> Teachers showed additional maturity in the mean level of their concerns (p = .004) and their most frequently listed concern was more student-oriented (p = .001).

TABLE 4

Group I Change in Teacher Attitudes Through Four Trials (TSD)

(one-group-four-trials analysis of variance)

Protocol	Trial 1 Group Mean	Trial 2 Group Mean	Trial 3 Group Mean	Trial 4 Group Mean	Groups by Trials F Ratio
Institute (Range 4–28)					
Ev.	25.00	23.64	26.12	25.52	3.489**
Po.	21.16	18.68	20.86	20.88	3.899**
Act.	23.00	21.20	23.04	23.00	2.605*
School Situation (Range 12–84)					
Ev.	55.08	51.12	54.40	51.20	1.878
Po.	54.72	55.64	56.68	55.64	.322
Act.	52.56	52.68	54.40	52.40	.393
Teaching as a Job (range 12–84)					
Ev.	73.84	73.04	73.72	71.28	.820
Po.	67.40	64.72	66.00	65.48	.950
Act.	69.28	68.16	70.04	67.04	.748
Self as a Science Teacher (Range 8–56)					
Ev.	46.32	43.20	46.56	45.36	2.279
Po.	42.08	39.88	42.00	42.28	1.662
Act.	43.00	41.60	42.96	43.24	.492

*sig. .05
**sig. .01

Group I (2 year study) N=26

TABLE 5

Change in Teacher Self-Evaluation Through Two and Three Trials (ASIST)
(one-group-two/three-trials analysis of variance)

ASIST + Subscale Range 0–4	Group	Trial 1 Group Mean	Trial 2 Group Mean	Trial 3 Group Mean	Trial 1–2 F Ratio	Trial 1–2–3 F Ratio
A.	I	1.8931	3.6472		26.420***	
	II	2.2048	2.5938		12.083**	
	III	1.8496	2.5715	2.5346		14.648***
B.	I	2.8098	3.0811		2.386	
	II	2.9886	3.2010		4.234*	
	III	2.7692	2.9900	2.5346		5.783**
C.	I	2.1781	2.7144		8.486**	
	II	2.5514	2.8834		10.287**	
	III	2.0377	2.6935	2.9031		7.354***
D.	I	2.5662	3.0753		12.557***	
	II	2.9341	3.1114		2.420	
	III	2.5312	3.0442	2.9504		7.657**
E.	I	1.9459	2.8312		5.082*	
	II	2.1655	2.3934		2.359	
	III	1.9796	2.3115	2.2254		2.227
F.	I	1.5809	2.8312		10.577**	
	II	1.7669	2.3500		15.870***	
	III	1.4785	2.0823	3.5973		6.128**
G.	I	1.2572	2.1706		17.786***	
	II	1.9724	2.4076		4.945*	
	III	1.3281	2.1319	2.1215		8.411***
Total	I	2.0250	2.6116		16.978***	
	II	2.3817	2.7000		15.876***	
	III	1.9738	2.5758	2.5358		8.977***

+ THE PROFESSIONAL SCIENCE TEACHER:
A. is well educated in science and the liberal arts.
B. poses a functional philosophy of education and the technical skills of teaching.
C. continues to grow in knowledge and skill during his career.
D. insists on a sound educational environment in which to work.
E. maintains his professional status.
F. contributes to the improvement of science teaching.
G. takes a vital interest in the quality of future science teachers.

* sig. .05
** sig. .01
***sig. .001

Group I (SI '71)
N=32

Group II (SI '72)
N=30

Group III (SI '71 - 2 year study)
N=26

TABLE 6

Changes in Level of Teacher Concern Through Three and Four Trials (TCS)
(one-group-three/four-trials analysis of variance)

TCS Measure Range 0–6	Group	Trial 1 Group Mean	Trial 2 Group Mean	Trial 3 Group Mean	Trial 4 Group Mean	by Trials F Ratio Groups
Mean	I	4.2937	4.6911	4.8344		4.215*
	II	4.5310	4.5828	3.9655		2.931
	III	4.3538	4.7923	4.7308	3.8428	4.750**
Mode	I	4.4063	4.9357	5.0938		6.636**
	II	4.5517	4.6552	4.0000		2.873
	III	4.4231	5.0000	5.0000	3.9231	6.027**
Most	I	4.4326	4.6874	4.8790		4.166
	II	4.6207	4.8276	4.1379		2.605
	III	4.3077	4.6923	4.7300	4.0385	2.214

*sig. .05
**sig. .01

Group I	(SI '71)	N=32
Group II	(SI '72)	N=30
Group III	(SI '71 - 2 year study)	N=26

CONCLUSIONS

The findings indicate that there was only partial positive group effect on the attitudes of Group II participants' students toward the world of science. Group I showed no change at the close of the first year, but the second year study revealed a possible beginning of student attitude change. The changes found in this study were not as great as those found by Butts and Raun (1969), Ost (1971), or Yager (1966) who reported on institutes specially structured to achieve attitude change. Both institutes in this study were designed to improve teacher content competencies as a means of increasing teaching effectiveness with no special attention given to the affective domain.

There was an apparent negative effect on participant attitudes immediately following the institute that was reversed during the following year of teaching. This suggests that teachers came to the institute with high expectations; yet, after nine weeks of intensive work, they apparently experienced a let-down of feeling at the close of the institute that was replaced by a return to "normal" by the close of the following year. This was accompanied by an increasing respect for the value of the institute itself once participants had had the opportunity to employ the competencies, skills, and techniques acquired during the institute. These results point out that in many instances, short term measurements, such as those taken at the end of the institute, may not accurately reflect the real effect on subsequent attitudes.

The professional self-perception of all participants was markedly improved. The teachers' evaluation of themselves as professional science teachers improved significantly by the close of the institute and continued to grow during the following years of teaching.

Less success was noted in the ability of the participants to increase the maturity of their concerns about teaching. Teachers in 1971 were found to be more mature at the close of the institute and continued to increase in maturity during the following years. Teachers in the 1972 SI failed to show maturation due primarily to the inclusion of an increasing number of O level concerns dealing with job security for the 1973 teaching year, a time when the number of surplus teachers was increasing.

The lack of certain definite positive attitude changes may have been influenced by several factors. There was no control over the comparability of students selected by participants for inclusion in this study and the degree of confidence established with the student groups prior to measurement is unknown. Teachers who applied for and were accepted as participants would be expected to come to the institute with pre-existing high positive attitudes and concerns that would be difficult to increase. Finally, the early 1970s were a time of foment and uncertainty in the world of education for both students and teachers that would surely be reflected in their attitudes.

This study stresses the need for further long range studies in the affective domain in order to uncover changes not exposed in short term measurements. It is indicated that certain aspects of this domain may be positively altered by such institute involvement.

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CHANGES IN SCIENCE TEACHER CLASSROOM BEHAVIOR FOLLOWING INVOLVEMENT IN A SUMMER INSTITUTE EMPLOYING MODELING TECHNIQUES

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INTRODUCTION

Inservice education is commonly used to improve science teaching and increase teacher effectiveness. Yet, rarely is the teacher-student interaction a part of either the inservice program or the evaluation of its effects (Fischler and Anastasiow, 1965). Little has been done to measure the effectiveness of such programs as they relate to teacher classroom behavior change.

Studies reported by Veldman and Peck (1963), Ryans (1964), Kochendorfer (1967), Ost (1971) and others express agreement that students are the most reliable, valuable raters of their teacher's classroom behavior.

Frequently institutes include special methods courses in their offerings to facilitate the alteration of teacher classroom behavior toward more desired and appropriate behaviors. The National Science Foundation (NSF) sponsored institutes usually offer purely content courses so that new strategies and methods must be informally introduced by outside readings, discussion, or the use of modeling techniques which employ the use of the desired new strategies while teaching the course.

The problem presented in this study is to ascertain to what degree the use of these modeling techniques during content presentation can be shown to have met the challenge of altering teacher classroom behavior in the desired direction.

The University of Texas at Austin has offered NSF sponsored teacher retraining institutes every summer since 1957. These Summer Institutes (SI) are "unitary" in that they are designed to up-date primarily the content competencies of participants. The institutes originally offered science content courses for senior high school teachers, but have recently concentrated on teachers in middle schools.

THE STUDY

The subjects for this study attended one of two inservice institutes offered in the summer of 1971 and 1972. Teacher classroom behavior was determined in April before institute involvement and again the following April after participants had been back in their classrooms working with students for eight months. This research design is identified by Campbell and Stanley (1970) as One-Group-Pretest-Posttest.

There were 48 participants in the SI program of 1971 and 40 in the 1972 program; data from both groups were combined in this study. At the close of the study, 26 of the total population of 88, roughly 30%, did not complete the follow-up measurements. Fourteen teachers had remained at the university working toward advanced degrees, four were no longer responsible for science classes, two were not available due to health reasons, and four did not respond. This left a population of 62 from which three groups were taken. Of the teachers used, 18 taught earth science, 15 physical science, and 15 taught biological or life science. Each taught in his area before and after the institute and was enrolled in the corresponding institute content course. The remaining participants failed to meet these criteria.

THE INSTRUMENT

Teacher classroom behavior was determined by the *Science Classroom Activity Checklist* (SCAC) which is a modified form of Kochendorfer's (1967) Biology Classroom Activity Checklist. It is composed of 53 statements descriptive of activities in science classrooms. The statements are grouped into seven categories according to activity: Role of the Teacher, Class Participation, Use of Curriculum Materials, Tests, Pre-laboratory, Laboratory, and Post-laboratory. This instrument yields seven subscale scores plus the total score. The students respond to it in a TRUE/FALSE manner depending on whether the activity described occurs frequently in their classrooms or not. Twenty-six items were determined desirable by a panel of judges whose ratings had an intraclass correlation coefficient of .96. A TRUE response to any statement of a desirable activity or FALSE to an undesirable one was counted as a correct response. The class mean score for each subscale and the total were recorded as the participant's score. These SCAC scores were then compared, pre-treatment to post-treatment, by analysis of variance to determine any change present and its level of significance. The three groups were thus examined individually and in combination.

INSTITUTE COURSES AND INSTRUCTORS

The Physical Science course was based on the *Physical Science Resource Guide* developed by the Texas Education Agency for use with ninth-grade physical science students. The guide stresses student operational understanding of concepts through laboratory experiences. The instructor had been on the project writing team and was familiar with modeling the student-oriented, laboratory-centered teaching approach used.

The Earth Science course was based on Earth Science Curriculum Project's *Investigating the Earth*. The instructor was a part of the writing team for this project and was well versed in the use of modeling techniques. This course stressed the proper use of the ESCP materials in a student-laboratory-centered approach to teaching science.

The Biological Science course was taught by different instructors each summer. In 1971, the course was based on ecological problems presented by lecture and independent study projects. The 1972 course lectures covered a wider range of topics. The Biological Science Curriculum Study's *Laboratory Block: Plant Growth and Development* was used for the laboratory section during both years.

Due to differences in content and methodology of the three institute courses, there were two groups (Earth Science and Physical Science) in which student-oriented modeling techniques were used and one group (Biological Science) in which the lecture technique coupled with a laboratory section was used primarily.

RESULTS

Data from all three groups were combined to determine change in teacher classroom behavior for participants who had tested in one area, enrolled in that institute area course, and retested in the same area. Results of the one-group-two-trials analysis of variance are given in Table 1.

This analysis suggests that when teachers who had been working in a content area came to an inservice institute and received instruction in that content area, returned to the classroom and made use of their newly acquired insight and knowledge, there was a dramatic change in their teacher classroom behavior as perceived by their students based on data for the entire group. However, the purpose of this study was to focus primarily on the effects of modeling student-centered techniques to determine their potential effect in bringing about this change.

TABLE 1

Change in Teacher Classroom Behavior for Total Group Through Two Trials
(one-group-two-trials analysis of variance)

SCAC Subscale		Range	Trial 1 Group Mean	Trial 2 Group Mean	Groups by F Ratio	Probability
A.	Role of the Teacher	0–8	4.5510	4.7971	5.473	.0223*
B.	Class Participation	0–8	4.3452	4.6275	8.719	.0051**
C.	Use of Curriculum Materials	0–7	3.4990	3.6455	4.050	.0472*
D.	Tests	0–6	2.9169	3.1293	4.156	.0445*
E.	Pre-laboratory	0–8	4.2711	4.5460	6.998	.0100**
F.	Laboratory	0–9	4.6827	5.0576	6.507	.0135*
G.	Post Laboratory	0–7	3.6728	4.0944	16.001	.0004***
	Total Score	0–53	27.9181	29.8880	22.365	.0001***

*= .05 level of significance
**= .01 level of significance
***= .001 level of significance

N=48

To examine the change in teacher behavior in each of the three content areas the data were examined by three-groups-two-trials analysis of variance. Results of this further analysis (Table 2) indicate that after the institute the following changes were found:

TABLE 2

Changes in Teacher Classroom Behavior Before and After Institute Participation

SCAC			Earth Science			Physical Science			Biological Science		
Subscale	Range	Trial	Group Mean	F Ratio	P	Group Mean	F Ratio	P	Group Mean	F ratio	P
A	0–8	1 2	4.5903 4.8696	3.744	.0670	4.4015 4.6068	.921	.3557	4.6533 4.9006	1.435	.2498
B	0–8	1 2	4.3282 4.6772	6.808	.0175*	4.1461 4.5230	3.199	.0924	4.5648 4.6723	.472	.5095
C	0–7	1 2	3.4192 3.6781	7.655	.0127*	3.2905 3.5655	3.282	.0886	3.8032 3.6864	.980	.3406
D	0–6	1 2	2.6304 2.8841	2.639	.1195	3.0387 3.4500	7.968	.0131*	3.1389 3.1029	.025	.8718
E	0–8	1 2	4.5292 4.6601	2.755	.1121	3.8814 4.5892	6.634	.0210*	4.3513 4.3658	.019	.8883
F	0–9	1 2	4.8192 5.1352	3.216	.0876	4.3894 5.2229	4.529	.0384*	4.8122 4.9990	.533	.4833
G	0–7	1 2	3.7655 4.0624	4.974	.0375*	3.2240 3.9859	13.113	.0030**	4.0104 4.2415	1.440	.2489
Total Score	0–53	1 2	28.1200 30.1248	16.205	.0012**	26.2651 29.7405	24.354	.0004***	29.3287 29.7515	.265	.6197

Levels of significance:
*=.05
**=.01
***=.001

SCAC Subscales:
A. Role of the Teacher
B. Class Participation
C. Use of Curriculum Materials
D. Tests
E. Pre-laboratory
F. Laboratory
G. Post-laboratory

Group I	Earth Science	n=18
Group II	Physical Science	n=15
Group III	Biological Science	n=15

1) Earth science teachers spent less time having students write study questions and memorize class notes. Instead, they allowed students to discuss scientific ideas, look for the thinking behind scientific conclusions, and to do their own laboratory demonstrations (Subscale B, Class Participation, $p = .0175$).

2) Earth science teachers used the text less as a source of facts and definitions for students to memorize or outline and more as a source of knowledge for class discussion of problems and evidence to support their answers (Subscale C, Use of Curriculum Materials, $p = .0127$).

3) Earth science teachers placed less stress on notebooks graded primarily for neatness as the main product of the laboratory exercise; instead they followed up the laboratory with a discussion of all results, compared and graphed all data, and analyzed all conclusions drawn by the students (Subscale G, Post-laboratory $p = .0375$).

4) Earth science teachers were less authoritarian than they had been and they employed more student-centered practices (Total score $p = .0012$).

5) Physical science teachers tested less for rote memorization and definitions or drawings to be labeled; testing instead was equally based on laboratory experiences and class discussion, leading students to analyze new problems and draw independent conclusions (Subscale D, Tests $p = .0131$).

6) Physical science teachers spent more time discussing laboratory problems and the means of investigating them with an open mind, instead of explaining step-by-step what the students were to do in the laboratory and what they were to find in the exercises (Subscale E, Pre-laboratory $p = .0210$).

7) Physical science teachers used the laboratory less as a means of "proving facts" presented in lectures and were more open-minded with problems and procedures often developed by the students guided by the teachers questions to interpret the text material (Subscale F, Laboratory $p = .0384$).

8) Physical science teachers followed up the laboratory experiences with discussion of all results and led the students to compare and graph all data and analyze their conclusions (Subscale G, Post-laboratory $p = .0030$).

9) Physical science teachers conducted more student-centered classrooms and were less authoritarian in their behaviors and more laboratory-centered (Total score $p = .0004$).

10) Biological science teachers did not exhibit any significant changes in their teacher classroom behaviors before and after the institute.

CONCLUSIONS

The statistical findings of this study tend to indicate that participation in an inservice retraining institute, where teachers study in the area of their teaching responsibility and subsequently return to that same teaching area, works to alter the classroom behavior of the teacher during the year of teaching immediately following the institute. The teacher whose instructor utilized modeling techniques to impart desired classroom strategies and new teaching methods showed significantly greater change than teachers whose instructors used the lecture or lecture-laboratory methods of class presentation.

Retraining teachers by use of student-oriented materials and imparting new teaching strategies and methods through modeling techniques seems to be a feasible way of encouraging teachers to use more student-centered activities and newer teaching strategies in their own classrooms.

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THE DEVELOPMENT OF AN INSTRUMENT TO DETERMINE STUDENTS' VIEWS OF THE TENTATIVENESS OF SCIENCE

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INTRODUCTION

Sund and Trowbridge (1967) state that from ignorance of the limitations and uncertainties inherent in scientific concepts, students are led to expect behavior which does not occur. They further state that this is turn breeds cynicism about science and its value, a cynicism summed up by a total alienation of the idea of theory and practice, science and common sense. Later, due to the failure to understand science, students are led to treat conclusions as absolute truth. Sund and Trowbridge (1967) claim that later in life when these conclusions prove false, the student retreats from clarity to generalized suspicion of scientific conceptions and authority.

Fischer (1971) states there is a failure to stress, or even recognize, that science is not static, as is implied by such terms as "systematic" and "organized knowledge"; rather, it is very dynamic and is changing and continually developing. Science operates on a basis of probability, not certainty; yet many teachers approach science as a fixed body of knowledge of absolute truths, accumulated and dead. They do not give the student an understanding of the tentative and doubtful elements of science, nor do they enlighten the students about the types of evidence used in making tentative conclusions.

Frank (1957) claims that every American citizen would be well advised to try to understand both science and scientists as best he can; thus a method is needed to impart knowledge of the tactics and strategies of science to those who are not scientists.

Fischer (1971) states that the authority of science is the senses and this involves two-way interaction between the observer and that which is observed. According to Fischer (1971), the observer is affected or caused to respond through his senses; the object or phenomenon being observed is also acted upon and may be changed.

This implies that views of the universe change as the observer changes. With this in mind, the *Views of Science* instrument was developed to accomplish the task of determining the students' views of the tentativeness of their universe.

DEVELOPMENT OF THE INSTRUMENT

The initial step in the development of the instrument was the determination of a method to select statements which imply science is either tentative or absolute. In order that the statements reflect either the tentativeness of science or falsely reflect in absolute terms the nature of science, it was necessary that they reflect the opinion of a spectrum of well-informed individuals. Since these statements dealt with the nature of science, it was considered necessary that people recognized in a field of specialization and with an expressed interest in the nature of science make up the panel of judges. Cooley (1970) states that instruments should be given to judges who have established a reputation in a special field as ascertained by their publications and by recommendations of people working in that field. He also states that the judges should have expressed interest in the nature of science as evidenced by publications, speeches, or participation in such discussions on state or preferably national levels.

Blanchet (1957) states that the size of a panel of judges needed to obtain reliable and valid results is not important if the evaluators are well qualified. Cooley (1970), Smith (1951), and Atwood (1971) state that individual evaluations by a panel of judges of as few as three individuals are both reliable and valid, within their frame of reference.

In the development of the *Views of Science* instrument, six judges, experts in their fields of specialization, were used in the first pool of statements and four of the judges were used in the second pool.

SELECTION OF VIEWS OF SCIENCE ITEMS

A pool of sixty-five statements about the tentativeness of science taken from science textbooks, philosophy of science books, or composed by the author constituted the first pool. These were submitted to a panel of six judges, composed of four professors of science education, one professor of philosophy of science, and one professor of the history of science. Two of the professors of science education were also professors of physics. The judges were asked to read each statement and rate it according to the following directions:

> Please indicate by marking "A" in column #1 if you agree with the statement.
>
> Please indicate by marking "D" in column #1 if you disagree with the statement.
>
> Please indicate by marking "U" in column #1 if you are uncertain about the statement.
>
> Please indicate by marking "A" in column #2 if you agree that the statement correctly implies or indicates that science is tentative in nature.
>
> Please indicate by marking "D" in column #2 if the statement incorrectly implies or indicates that science is certain or absolute in nature.
>
> Please indicate by marking "U" in column #2 if the statement does not imply or indicate either the tentativeness of science or the certainty of science.

Those items which received a majority of votes (i.e. 6–0, 5–1, 4–2) for representing the tentativeness or false certainty of science were considered for the final instrument. Only twenty-four items from the pool of sixty-five received a majority of votes; consequently, another pool of statements from the same sources as the first pool was constructed. The second pool was made up of forty-five statements and judged for content validity by four of the judges.

Items which received at least three votes for either tentativeness or absoluteness, with the remaining vote being uncertain, were selected for consideration for the final instrument. This means that, although an item may have received three votes for tentativeness and one vote for certainty, it was not selected to be part of the final instrument. Eighteen items from the pool were selected.

A total of forty-two statements were judged to be implying that science is either tentative or falsely absolute in nature. Two statements selected were discarded by the investigator because of difficulty in wording, leaving a total of forty items in the final instrument.

VALIDITY

Construct validity was evaluated by a method described by Shaw and Wright (1967) which involves a determination of the relationship between the attitude score and other aspects of the personality. According to Anastasi (1954), validation by the method of contrasted groups generally involves a composite criterion which reflects the cumulative and uncontrolled selective influences of everyday life. The contrasted groups are distinct groups which gradually become differentiated through the operation of the multiple demands of daily living. In this study, the method called the known-groups technique was used. It was expected that the four groups in the developmental study would differ in their mean scores on the *Views of Science* instrument according to their level of involvement in science education. It was expected that the groups composed of teaching assistants (TA) who were graduate students working on advanced degrees and teaching an inquiry-oriented physical science course would have the highest mean because they were closest to the level of judgmental authority. This group would be followed by the secondary school science teachers (SST), the college physical science students (P.S.) and the ninth-grade physical science students (Table 1).

TABLE 1

The Mean Scores of Four Test Groups on VS

Group	#1=TA	#2=SST	#3=P.S. 303	#4=P.S. 9th grade
$\overline{X}$	164.50	156.07	150.57	139.24

The *Views of Science* instrument was given to the four groups in March, 1974. The summary of the results may be found in Table 1. It can be seen that teaching assistants had the highest mean, followed by secondary school teachers, followed by college physical science students, followed by secondary ninth-grade physical science students. Analysis of variance for the mean scores of the four test groups (Table 2) indicates that the differences in mean scores for each group were significantly different from any of the other three groups. Thus, validation by the method of contrasted groups was determined.

Concurrent validity was established as a part of the battery of tests used in the author's research study. Correlations between class means on the *Views of Science* (VS), the *Watson-Glaser Critical Thinking Appraisal* (WGCTA), and the *Science Classroom Activity Checklist* (SCAC) are reported in Table 3.

TABLE 2

Multiple Group Analysis of Variance (T-TEST) for The Mean Scores of the Four Test Groups

Group	N	Mean Score	r	p
1	8	164.50	1.76	.05
2	26	156.05		
1	8	164.50	2.94	.01
3	42	150.57		
1	8	164.50	5.35	.01
4	33	139.24		
2	26	156.07	1.83	.05
3	42	150.57		
2	26	156.07	5.63	.01
4	33	139.24		
3	42	150.57	3.91	.01
4	33	139.24		

TABLE 3

Concurrent Validity for Views of Science

Factor	Means	r	p
VS	132.89		
WGCTA	56.51	.7559	.01
SCAC	56.55	.4386	.05

The fact that correlation coefficients for WGCTA and SCAC are greater than .361 (.05 level of significance) gives evidence of the substantial relationship existing between the views of the tentativeness of science as measured by *Views of Science* and the following: (1) critical thinking skills and (2) students' perception of the degree to which science classroom activities are inquiry oriented.

RELIABILITY

Any research based on measurement must be concerned with the accuracy or dependability or, as it is usually called, reliability of measurement. To compute the reliability of the *Views of Science* test, an Alpha coefficient of internal consistency was computed.

The reliability coefficient was computed for each group. Anastasi (1954) states that each reliability coefficient should be accompanied by a description of the type of group on which it was determined because the reported reliability coefficient is applicable only to samples similar to that on which it was found. Using the responses of the individuals in the four groups, the following Alpha coefficients were computed:

Group 1: Teaching Assistants of Physical Science 303,304: + .82
Group 2: Secondary Science Teachers: + .75
Group 3: College Physical Science Students: + .81
Group 4: Ninth-Grade Physical Science Students: + .71

POTENTIAL USE

Many curriculum projects emphasize that teacher practices and student critical thinking skills are important to their successful use. Research supports that teacher practices and student critical thinking skills and attitudes are related to the students' views of the tentativeness of science. It has been advocated that science students should view science as dynamic, flexible, and tentative. The *Views of Science* instrument allows researchers to determine if teacher practices are accomplishing this objective.

SUMMARY

The purpose of this project was to develop a valid, yet easy to administer, instrument to be used in determining student views toward the tentativeness of science. A list of forty items was selected by a panel of judges. The statements selected were judged to imply either that science was tentative or absolute in nature. The final instrument was administered to 34 teachers and to over 700 students for computation of validity and reliability.

VIEWS OF SCIENCE

The following list contains items related to the views of science. Please check the blank by each item which is most representative of your view of science: SA– strongly agree, A– agree, U– undecided, D– disagree, SD– strongly disagree.

	SA	A	U	D	SD
1. We all see the same moon because the moon is out there, outside ourselves, for all to see.					
2. Our laws of science, especially any developed within the last ten years, are not likely to ever be changed.					
3. Scientists do not agree entirely on the basic concept of the atom.					
4. It is impossible to eliminate error and uncertainty from the measurement process, even with the very best equipment.					
5. Atoms are thought to exist, but this has not been observed directly.					
6. Science has gradually discovered that its nature, standing by its own strength, was an assumption rather than an established fact.					
7. When the same experiment is performed any number of times, under exactly the same circumstances, the result is necessarily always the same.					

	SA	A	U	D	SD
8. In practice, the scientist follows a rigid step-by-step procedure in solving problems to insure accurate results.					
9. Anything observable can be measured exactly.					
10. We cannot experience the whole of nature; consequently, we can never hope to understand it completely.					
11. In sending Apollo 11 and Apollo 12 to the moon, many assumptions were made because they are essential in scientific thinking.					
12. Since scientific knowledge is changing all the time, scientific ideas are subject to being revised or thrown away.					
13. Scientists do not know if the mass remains the same during chemical reactions, but they do know if any change occurs it must be small.					
14. Scientific knowledge is constantly subject to revision.					
15. There is no reason why we cannot obtain knowledge and have it change with the passage of time.					
16. Scientists using the very best instruments can measure things exactly.					
17. Science is the true and certain way to solve problems of nature and of man.					
18. When two people observe a chair, the sensations which this produces will never be quite identical to both people.					
19. Most laws of nature have been discovered.					
20. We can never say that any theory is final or corresponds to absolute truth because, at any moment, new facts may be discovered and compel us to abandon it.					
21. In sending Apollo 11 and Apollo 12 to the moon, no assumptions were made because everything had to be certain.					
22. No two men ever observe the same rainbow in the same way.					
23. It has been proven that there is no gain or loss of mass in any chemical reaction.					
24. Scientific laws can be proven to be true.					
25. Scientists will never be able to discover the exact position and exact speed of motion of every particle in the universe.					
26. Our knowledge of nature can be visualized, little by little, in a number of different pictures, although no single picture enables us to visualize the whole of nature at once.					
27. The scientist is content with a single exact observation.					
28. In science, most evidence is arrived at or derived from some particular set of experimental data and then extended to an all-embracing law.					
29. The development of new scientific instruments, as the electron microscope, made exact measurements possible.					
30. Scientific laws are not provable in a classroom or in a well-equipped laboratory.					

31. In laboratory experiments, it is impossible to record all possible observations.

32. The picture or model provides a representation, not of objective nature, but only of our knowledge of nature.

33. Observations are often very difficult to explain in terms of scientific laws.

34. We can know nothing of the world outside ourselves for certain.

35. The scientist no longer sees nature as something entirely distinct from himself. SA A U D SD

36. A measurement depends on the object being measured, the measuring instrument and the observer.

37. With the exception of counting a small number of objects, there is always uncertainty and/or error in measurement.

38. When an experiment is repeated several times under identical conditions, several different results may be obtained.

39. Scientists do not expect a model to be permanently successful.

40. The notion that scientific knowledge is certain is an illusion.

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THE RELATIONSHIP BETWEEN INQUIRY ORIENTATION IN SECONDARY PHYSICAL SCIENCE CLASSROOMS AND STUDENTS' CRITICAL THINKING SKILLS, ATTITUDES AND VIEWS OF SCIENCE

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INTRODUCTION

At all levels of education, the inquiry or process approach is being advocated in the science curricula. New materials are giving attention to the investigatory aspects, and the teacher is becoming more of a director of research than a dispenser of knowledge (Sund and Trowbridge, 1967).

All too often, school science has been characterized by an over-emphasis on content (Fields and Cropley, 1969), while the use of information for adaptive purposes to create new ideas or cope with strange or novel settings has received too little attention. Teaching school science is teaching students to be alive, dynamic and thinking human beings (Sund and Trowbridge, 1967). Gagnè (1963) states that knowledge of principles is a prerequisite to the successful practice of the techniques of inquiry, plus incisive knowledge–discriminating ability. This does not mean that thinking follows naturally out of knowing.

Ramsey and Howe (1969) claim that a student's attitude toward science may well be more important than his understanding of science since his attitudes determine how he will use his knowledge. For this reason the development of attitudes and views as a part of science education is an area requiring increasing research.

THE PROBLEM

This study was designed to permit the author to investigate the relationships between teacher attitudes toward inquiry teaching strategy, the degree of inquiry orientation in science classroom activity, students' critical thinking skills, attitudes toward the science curriculum (science class, science laboratory, science teacher, school), and views of the tentativeness of science.

The general hypotheses developed and investigated were:

Hypothesis 1: There is no relationship between teachers' attitudes toward inquiry teaching strategies and students' critical thinking skills, attitudes toward the science curriculum, and views of the tentativeness of science.

Hypothesis 2: There is no relationship between the degree to which the science classroom activities are inquiry oriented and students' critical thinking skills, attitudes toward the science curriculum, and views of the tentativeness of science.

THE STUDY

The sample used in the research problem consisted of ninth grade physical science teachers and one representative classroom for each teacher from a wide geographical area of the State of Texas. The following procedure was used in obtaining teachers and students for participation in the research: a list of names and addresses of members of the Texas Science Supervisors Association was obtained and each supervisor on the list was asked to identify teachers willing to participate in the study, if the school district was willing to allow the study. Additional letters were sent to science department chairmen or secondary supervisors in school districts without science supervisors. Thirty physical science teachers and a total of 671 ninth-grade physical science students in sixteen secondary schools in ten school districts agreed to participate in the study.

During the month of April, 1974, the testing instruments were administered to the participants. The class means of the thirty classes as well as student scores were used in the statistical operations of the study.

Five instruments were utilized in collecting necessary data for the study. One instrument, the *Inquiry Science Teaching Strategy* (ISTS), was administered to the teachers to gather the teacher's attitude toward inquiry teaching strategies. Four instruments—*Watson-Glaser Critical Thinking Appraisal*, *Osgood's Semantic Differential*, *Science Classroom Activity Checklist*, and the *Views of Science* were used to gather students' critical thinking skills, attitudes toward the science curriculum, students' perceptions of teacher classroom practices, and views of the tentativeness of science, respectively.

Since no instrument was available to determine a student's view of the tentativeness of science, the first part of this study was to develop one for this purpose. Descriptions of the development and evaluation of the instrument, *Views of Science* (VS) as well as a copy of the instrument itself are found elsewhere in this monograph (Hillis, 1975).

RESULTS:

The purpose of this study was not to find out if one method was "better" than another method; but, instead, was to determine the relationships of the students' critical thinking skills, attitudes toward the science curriculum, and views of the tentativeness of science to the following factors: teacher attitude toward inquiry teaching strategies and the degree to which the science classroom activities are inquiry oriented. Two questions were generated from this problem and will now be discussed.

Question 1: Is there a relationship between teacher attitudes toward inquiry teaching strategies and students' critical thinking skills, attitudes toward the science curriculum, and views of the tentativeness of science?

In discussing this question, the following null hypotheses were tested:

Hypothesis 1.1: There is no relationship between teachers' attitudes toward inquiry teaching strategies and their students' critical thinking skills.

Hypothesis 1.2: There is no relationship between teachers' attitudes toward inquiry teaching strategies and their students' perceptions of the degree of inquiry orientation in the science classroom activities.

Hypothesis 1.3: There is no relationship between teachers' attitudes toward inquiry teaching strategies and their students' attitudes toward the science class.

Hypothesis 1.4: There is no relationship between teachers' attitudes toward inquiry teaching strategies and their students' attitudes toward the science laboratory.

Hypothesis 1.5: There is no relationship between teachers' attitudes toward inquiry teaching strategies and their students' attitudes toward the science teacher.

Hypothesis 1.6: There is no relationship between teachers' attitudes toward inquiry teaching strategies and their students' attitudes toward the school.

Hypothesis 1.7: There is no relationship between teachers' attitudes toward inquiry teaching strategies and their students' views of the tentativeness of science.

To test these hypotheses, Pearson Product Moment Correlation Coefficients were computed.

To test Hypotheses 1.1 through 1.7, the teachers' scores on the ISTS instrument (Lazarowitz, 1973) were used as the first variable. In Hypothesis 1.1, the students' class mean scores on the *Watson-Glaser Critical Thinking Appraisal* served as the second variable. For Hypothesis 1.2, the SCAC class mean scores were used as the second variable. For Hypotheses 1.3 through 1.6, the students' class mean scores on attitudes toward the science class, science laboratory, science teacher, and school were used as the second variable. To test Hypothesis 1.7, the students' class mean scores from the *Views of Science* constituted the second variable. A summary of the results for the above hypotheses may be found in Table 1. In reading the tables with respect to the attitude objects, the dimensions of the *Semantic Differential* have been abbreviated in the following manner: Ev.— evaluative factor; Po. — potency factor; and, Act. — activity factor.

The correlations for all hypotheses except null Hypothesis 1.6 are not significant; therefore, they are not rejected. The power dimension of the students' attitude toward the school is significant at the .01 level. The figures in Table 1 indicate that the more favorable the teacher's attitude toward inquiry teaching strategies the less powerful that teacher's students view the school to be.

Question 2: Is there a relationship between the degree to which the science classroom activities are inquiry oriented and students' critical thinking skills, attitudes toward the science curriculum, and views of the tentativeness of science?

To answer this question, the following null hypotheses were tested:

Hypothesis 2.1: There is no relationship between the degree of inquiry orientation in science classroom activities and students' critical thinking skills.

The results shown in Table 2 indicate there is a positive correlation between the degree to which the science classroom activities are inquiry oriented and students' critical thinking skills; however, more detailed analysis (Tables 3 and 4) indicate this correlation is positive for Anglo boys, Anglo girls, and non-Anglo girls. Hypothesis 2.1 is therefore accepted for the non-Anglo boys.

TABLE 1

Summary of Correlations Between Teacher's Attitude Toward Inquiry Teaching Strategies and Students' Critical Thinking Skills, Attitudes, and Views of Science

FACTOR	MEANS	r	p
First Variable			
ISTS	149.63		
Second Variables			
SCAC	56.55	.2493	ns
WGCTA	56.51	.0124	ns
VS	132.89	.2127	ns
Science Class			
Ev.	18.54	—.0125	ns
Po.	17.62	.0868	ns
Act.	17.39	—.0713	ns
Science Laboratory			
Ev.	20.09	—.0815	ns
Po.	17.41	—.0864	ns
Act.	18.74	.0273	ns
Teacher			
Ev.	20.32	.1302	ns
Po.	16.83	—.2387	ns
Act.	18.06	.1041	ns
School			
Ev.	18.71	—.3341	ns
Po.	19.78	—.5673	.01
Act.	18.25	—.3353	ns
Levels of Significance	.05	.361	
	.01	.463	

Hypothesis 2.2: There is no relationship between the degree of inquiry orientation in science classroom activities and students' attitudes toward the science class.

The results shown in Table 2 indicate there is a positive correlation between the degree to which the science teacher's behaviors are inquiry oriented and how highly students value the science class. Table 2 shows no significant correlations between the degree of inquiry orientation in the science classroom activities and how active the students view the science class to be or how powerful they view it to be. Therefore, the evaluative factor of null Hypothesis 2.2 is rejected. Tables 2, 3, and 4 show no significant correlations between how potent students view the science class to be and the degree to which the science class is inquiry oriented. The potency factor of null Hypothesis 2.2 is therefore accepted. A more detailed analysis (Tables 3 and 4) indicates that this correlation is significantly

TABLE 2

Summary of Correlations Between Science Classroom Activity and Students' Critical Thinking Skills, Attitudes, and Views of Science

FACTOR	MEANS	r	p
First Variable			
SCAC	56.55		
Second Variables			
WGCTA	56.51	.3847	.05
VS	132.89	.4386	.05
Science Class			
Ev.	18.54	.3987	.05
Po.	17.62	−.0074	ns
Act.	17.39	.2542	ns
Science Laboratory			
Ev.	20.09	.3520	ns
Po.	17.41	.1242	ns
Act.	18.74	.1602	ns
Teacher			
Ev.	20.32	.4941	.01
Po.	16.83	.0188	ns
Act.	18.06	.3253	ns
School			
Ev.	18.71	−.3753	.05
Po.	19.78	−.3561	ns
Act.	18.25	−.1182	ns
Levels of Significance	.05	.361	
	.01	.463	

positive for Anglo boys and non-Anglo girls. The activity factor of null Hypothesis 2.2 is therefore accepted for Anglo girls and non-Anglo boys.

Hypothesis 2.3: There is no relationship between the degree of inquiry orientation in science classroom activities and students' attitudes toward the science laboratory.

Table 2 shows no significant correlations between the degree of inquiry orientation in teachers' behaviors in science classrooms and students' attitudes toward the science laboratory in either the evaluative, potency, or activity factors when class means were used as measuring units. Null Hypothesis 2.3 is therefore accepted. However, a more detailed analysis (Tables 3 and 4) indicates this correlation is significantly positive for the evaluative factor for Anglo boys, Anglo girls, and non-Anglo girls. The evaluative factor of null Hypothesis 2.3 is therefore accepted for non-Anglo boys. Table 3 also indicates this correlation is significantly positive for the activity factor for Anglo boys. The activity factor of null Hypothesis 2.3 is therefore only accepted for Anglo girls, non-Anglo boys, and non-Anglo girls.

TABLE 3

Correlations Between the Degree of Inquiry Orientation in Science Classroom Activities and Critical Thinking Skills, Attitudes Toward the Science Curriculum, and Views of the Tentativeness of Science for Anglo Students by Sex

	ANGLO BOYS			ANGLO GIRLS		
FACTOR	MEAN	r	p	MEAN	r	p
SCAC	55.47			58.56		
WGCTA	56.57	.1778	.01	58.06	.1502	.01
VS	132.78	.3069	.01	134.53	.1135	.05
Science Class						
Ev.	18.44	.2566	.01	18.44	.1634	.01
Po.	17.80	.0191	ns	17.97	.0023	ns
Act.	17.43	.2010	.01	17.30	.0411	ns
Science Laboratory						
Ev.	20.02	.2389	.01	20.17	.1284	.05
Po.	17.57	.0742	ns	17.32	.0441	ns
Act.	19.00	.1674	.01	18.76	.0124	ns
Teacher						
Ev.	19.27	.2576	.01	21.60	.2293	.01
Po.	16.63	.1269	.05	16.75	−.0930	ns
Act.	17.85	.2446	.01	18.85	.1092	ns
School						
Ev.	17.54	.0455	ns	19.90	−.0960	ns
Po.	19.58	−.077	ns	19.96	−.0850	ns
Act.	17.49	.0168	ns	19.04	−.0060	ns
	N=282	BOYS		N=299	GIRLS	
Levels of significance						
	.05	.120			.113	
	.01	.160			.148	

Hypothesis 2.4: There is no relationship between the degree of inquiry orientation in science classroom activities and students' attitudes toward the teacher.

The results in Table 2 indicate there is a significant positive correlation between the degree to which teacher practices are inquiry oriented and how highly students value the science teacher. Tables 3 and 4 indicate the correlation is only significant for Anglo boys, Anglo girls, and non-Anglo girls. The evaluative factor of null Hypothesis 2.4 is therefore accepted for non-Anglo boys but rejected for Anglo boys, Anglo girls, and non-Anglo girls.

There is no significant correlation (Tables 2, 3, and 4) between the potency factor of students' attitudes toward the teacher and the degree of inquiry orientation in science classroom activities.

TABLE 4

Correlations Between the Degree of Inquiry Orientation in Science Classroom Activities and Critical Thinking Skills, Attitudes Toward the Science Curriculum, and Views of the Tentativeness of Science for Non-Anglo Students
By Sex

	NON-ANGLO BOYS			NON-ANGLO GIRLS		
FACTOR	MEAN	r	p	MEAN	r	p
SCAC	55.12			56.40		
WGCTA	50.79	.0825	ns	54.23	.3667	.05
VS	129.74	.1224	ns	131.36	.0953	ns
Science Class						
Ev.	20.74	.3125	.05	19.02	.4272	.05
Po.	17.79	−.0140	ns	16.04	.1516	ns
Act.	18.05	.1301	ns	18.19	.3104	.01
Science Laboratory						
Ev.	22.63	.2982	ns	20.51	.4076	.01
Po.	19.07	.1189	ns	17.28	−.0480	ns
Act.	18.63	.1377	ns	19.09	.2365	ns
Teacher						
Ev.	20.14	.2436	ns	21.36	.4515	.01
Po.	17.67	.2185	ns	18.13	−.0110	ns
Act.	17.14	.2200	ns	18.13	.4751	.01
School						
Ev.	19.70	.1111	ns	18.58	.2267	ns
Po.	19.88	−.1880	ns	19.28	−.0220	ns
Act.	18.88	−.0230	ns	17.58	.1076	ns
	N=43 Boys			N=47 Girls		
Levels of significance						
	.05	.304			.288	
	.01	.393			.372	

Table 2 does not indicate a significant correlation between the degree of inquiry orientation in science classroom activities and the activity factor of attitude toward the teacher; but, Tables 3 and 4 show this correlation to be significantly positive for Anglo boys and non-Anglo girls. The activity factor of null Hypothesis 2.4 is therefore accepted for Anglo girls and non-Anglo boys.

Hypothesis 2.5: There is no relationship between the degree of inquiry orientation in science classroom activities and students' attitudes toward the school.

Table 2 shows that when students' class mean scores are used as measuring units there is a significantly negative correlation between the degree to which the science classroom teacher's behaviors are inquiry oriented and how highly students value their school. The evaluative factor of null Hypothesis 2.5 is therefore rejected. The potency and activity factors of null Hypothesis 2.5 are therefore accepted. When fixed groups scores were used as measuring units, null Hypothesis 2.5 could not be rejected.

Hypothesis 2.6: There is no relationship between the degree of inquiry orientation in science classroom activities and students' views of the tentativeness of science.

When class means were used as measuring units (Table 2), there was a positive correlation between the degree to which the science teacher's practices are inquiry oriented as measured by the SCAC and the degree to which students view science as tentative. Therefore for students as a group, null Hypothesis 2.6 is rejected. Using student scores as measuring units does not permit rejection of this correlation for non-Anglo boys and girls.

To test the above hypotheses, Pearson Product Moment Correlation Coefficients were computed.

As shown in the discussion of Question 2, when students scores were used as measuring units, correlation coefficients were computed for groups differentiated by race and sex. This is especially meaningful in analysis of data when analysis using class means indicates no existence of a significant relationship between two variables. Fixed group analysis shows that while students in general show relationship or lack of relationship between two variables, certain groups differentiated in some way show significantly positive or negative correlations to exist, at least for that group between the two variables under consideration.

To further reveal differences in critical thinking skills, attitudes toward the science curriculum, and views of the tentativeness of science, a 2 × 2 analysis of variance was computed. Through the analysis unweighted means of the four fixed groups were used instead of raw scores because of unequal sample sizes of the groups. The fixed groups were:

Group 1,	N= 282	Anglo boys
Group 2,	N= 299	Anglo girls
Group 3,	N= 43	Non-Anglo boys
Group 4,	N= 47	Non-Anglo girls

The general hypothesis tested was:

> There is no difference between Anglo and non-Anglo students or between boys and girls in critical thinking skills, attitudes toward the science curriculum, and views of the tentativeness of science.

Analysis of data reveals that Anglo students have higher critical thinking skills, feel the science class is a more powerful force, and view science as more tentative than do non-Anglo students. Non-Anglo students seem to more highly value the science class and the science laboratory and view the science teacher as a more powerful person than do Anglo students.

The results of this study show that girls have higher critical thinking skills and more highly value the science teacher than do boys.

Non-Anglo girls seem to feel the science class is a less powerful influence than do Anglo boys, Anglo girls, and non-Anglo boys. Anglo girls and non-Anglo boys appear to value the school more highly and view it as more active than do Anglo boys and non-Anglo girls.

CONCLUSIONS

The analysis of data indicates no significant relationship between a teacher's attitude toward inquiry teaching strategies and a teacher's actual teaching practices in the science classroom. An examination of students' perceptions of teacher practices compared with the teachers' attitudes toward inquiry teaching strategies, reveals that a teacher's score on the ISTS instrument is a poor indicator of the teaching strategies the teacher will actually use in the science classroom. This means that a teacher may indicate a favorable attitude toward inquiry strategies but attitude toward inquiry strategies says little or nothing about what strategies a teacher is likely to use.

The data also show no significant relationship between a teacher's attitude toward inquiry teaching strategies and any student variable except the potency factor of student attitude toward the school. This implies that students whose teachers indicate a more favorable attitude toward inquiry teaching strategies view the school as being less powerful in nature than do students whose teachers have a less favorable attitude toward inquiry teaching strategies.

Analysis reveals a relationship does exist between inquiry teaching practices in the science classroom and students' critical thinking skills, attitudes toward the science curriculum, and views of the tentativeness of science. Students whose teachers have more inquiry oriented teaching practices have higher critical thinking skills, more positive attitudes toward the science class and science teacher, and view science as more tentative than do students whose teachers have less inquiry oriented teaching practices. Students in more inquiry oriented classrooms seem to more highly value the science class and teacher, and view them as being more active than do students in less inquiry oriented classes. Students in more inquiry oriented classes value the science laboratory more highly than do students in classes less inquiry oriented.

Student attitude toward the school was not related to the degree of inquiry orientation in the science classrooms when students were examined by race and sex. However, students as a whole reflect a negative relationship existing between the degree to which the science classroom activities are inquiry oriented and students' attitudes toward the school. This could be due to the group's positive attitude and response toward inquiry teaching practices used by the science teacher which is probably not used by teachers in other subject matter fields.

The study shows that race and sex are variables which are related to a student's critical thinking skills, attitudes, and views of science. Anglo students have higher critical thinking skills, value the science class and science laboratory less highly, view the science class as being more powerful and the teacher as less powerful; and, view science as more tentative than do non-Anglo students. Girls have higher critical thinking skills and seem to more highly value the science teacher than do boys. Non-Anglo girls seem to feel the science class is a less powerful influence than do Anglo boys, Anglo girls, or non-Anglo boys. Anglo girls and non-Anglo boys seem to more highly value the school and view it as more active in nature than do Anglo boys and non-Anglo girls.

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THE EFFECT OF AN INDUCTIVE LABORATORY-CENTERED APPROACH ON THE ATTITUDES OF NINTH-GRADE PHYSICAL SCIENCE STUDENTS

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INTRODUCTION

The Texas Education Agency *Physical Science Resource Guide* (1971) was developed as a joint effort involving scientists, science educators, science teachers, and the Texas Education Agency. It is designed for use in ninth-grade physical science.

Those working on the project recognized that for most students, ninth-grade physical science would be the last formal study in any of the physical sciences to which these students would be exposed. It would also likely be the last opportunity to provide students with experiences which could be instrumental in motivating them to pursue further study in the physical sciences.

The Texas Education Agency *Physical Science Resource Guide* has been designed to overcome some of the difficulties students experience in some science classrooms by reshaping the usual pattern of teaching science. The guide attempts to teach concepts through a structured inductive approach; that is, the initial focus is on direct experience with physical phenomena. From the direct observation of phenomena the student can be led to understand the behavior and verbalize this understanding in his or her own words. Eventually, through discussion, an accurate definition may be derived. The behavior, as described in the definition, can now be symbolized in the form of words or mathematical symbols.

If several groups of students in class are conducting the experiment, the first stage in the analysis of data involves having the students place their data on the blackboard in a class data table. The students place their name along side of their data. Through the use of class data the same experiment has been replicated many times. On occasion this data may then be placed on a bar graph. This usually presents the data in a form more easily interpretable by students. Through class discussion an inference can be made from the data.

The pattern followed then, is one of starting with a laboratory experience involving the phenomena to be studied, and then drawing an inference from class data. In turn, this inference may be combined with preceding laboratory findings in order to derive a description of a more generalized behavior. If appropriate, the generalization may be named and theoretical constructs then developed.

This pattern of teaching has several advantages over the usual approach. The process of collecting data in the laboratory keeps students actively involved and stimulated. Data collected by the students is recorded for all to see, and data collected by all of the students is used in drawing inferences. This not only helps generate emotional involvement, but also indicates to all students that what each student did in the laboratory is useful to the class. In this sense, no student has failed in the activity, and all have made a worthwhile contribution.

Another distinct advantage of using the inductive approach is that it closely parallels the actual development of concepts in science. This makes it very easy to develop an understanding on the part of students, not only of the nature of scientific concepts, but also the nature of the scientific enterprise.

This approach has the further advantage of providing flexibility in evaluation and grading. The primary criteria for determining grades may be quite different than those commonly used. For lower ability students the primary criteria for grading may be attendance, student willingness to do the activities in the laboratory and keep a notebook, and student participation in discussion. The use of these criteria allows science teachers to provide a situation in which all students at least have the opportunity for success. This is not to say that all students will achieve success, but the opportunity for success exists. Once students realize this, it is hoped the vast majority would undergo a change in attitude and motivation.

The developers of the *Physical Science Resource Guide* assumed that if a student, on the completion of a science course, leaves the course hating science, he would be better off never to have had the course. It was also assumed that students will learn more if they feel an experience involves something important and worthwhile. The improvement of student attitudes toward science instruction is therefore one of the primary goals of the *Physical Science Resource Guide.*

THE STUDY

A study was conducted to determine what effect the use of the activities in the guide would have on the attitudes of students after they had been exposed to this material for an entire school year.

Ten teachers who had been using the guide for the entire school year were chosen at random. Ten teachers who were teaching physical science but not using the guide also were chosen at random from a population of teachers who agreed to cooperate in the study. One class for each teacher was chosen at random, and a modified Osgood's Semantic Differential (1967) was given to the students in each of these classes during late spring. The 243 students whose teachers used the guide were labeled the experimental group, and the 240 students whose teachers did not use the guide were labeled the control group.

RESULTS

The evaluative factor of the Semantic Differential measures the basic attitudes of students with regard to how good, pleasant, and valuable the students perceived the situation. Table 1 shows the results when the two groups were compared with respect to this factor. The students who had experienced the approach presented within the guide had more positive attitudes toward their science classroom, science laboratory, science teacher, and school than did the control group. The fact that the attitudes of the two groups toward school were different indicates the broad significance of this approach.

The potency factor gives some indication of how large or awesome students

TABLE 1

Evaluative Factor

Variable	Experimental Group Means	Control Group Means	F	Probability
Science Class	22.4033	18.9583	43.674	.0000
Science Laboratory	23.4280	21.6125	14.515	.0004
Science Teacher	23.7119	22.2458	7.596	.0062
School	19.6214	18.0167	5.991	.0141

perceive a situation. The results, presented in Table 2, indicate that the students whose teachers had used the guide perceived their science class and school as less awesome. It should be noted that an attitude change of a fairly large magnitude must have occurred in order for the differences with regard to school to be detected. The lack of differences with regard to the science teacher likely indicated that the two groups of teachers were similar in size and stature.

TABLE 2

Potency Factor

Variable	Experimental Group Means	Control Group Means	F	Probability
Science Class	16.7654	18.1708	12.532	.0008
Science Laboratory	17.3045	17.9583	2.825	.0894
Science Teacher	18.3374	18.4000	.016	.8934
School	18.9095	20.5000	12.588	.0007

TABLE 3

Activity Factor

Variable	Experimental Group Means	Control Group Means	F	Probability
Science Class	18.7160	16.4042	24.851	.0000
Science Laboratory	19.6914	19.1333	1.620	.2008
Science Teacher	19.4568	18.4792	4.170	.0391
School	18.0658	17.7417	.393	.5382

The activity factor is a minor contributor to the overall attitude of a student, but it does indicate how active a student perceives a given situation or person. It can be noted from the results in Table 3 that students in science classrooms where the guide was being used perceived the science class and science teacher to be more active than those students in the control classroom. This likely indicates that both students and teacher become more actively involved when a laboratory approach is being used in the classroom.

CONCLUSIONS

The study just presented demonstrates that the use of a success-oriented, inductive approach, as represented by the Texas Education Agency *Physical Science Resource Guide*, does have a positive effect on student attitudes. Science educators increasingly are becoming concerned with the quality of education for all students and not just those pursuing a career in science. Many of the current problems with the negative feelings students have toward science can be traced to experiences provided them in science classes. An inductive, phenomenological approach seems to hold some promise in improving students' attitudes toward science instruction and hopefully toward science and scientists in general.

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PIAGET-BASED SEQUENCES OF INSTRUCTION IN SCIENCE: THE PENDULUM

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Mathematics is the basic instrument of science. It is the language scientists use to organize and clarify the regularities they believe occur in nature. Because of its important role in the progress of science, many people believe that mathematics is essential in science courses if the true character of the subject is to be portrayed. But, almost invariably, students at the secondary level have difficulties when faced with mathematics and quantitative reasoning in science courses.

Piaget (1951) has suggested that one of the causes of the students' difficulties with mathematical reasoning is the premature introduction of relationships in their quantitative form. He implies that students should have more time to work with problems at a qualitative level, identifying relevant factors and excluding inoperate ones and getting a feeling at a concrete level for the relationships that exist between factors. Piaget contends that

> "until the logical structure of the problem
> has been grasped, numerical considerations
> remain meaningless and serve only to conceal
> relationships involved." (Piaget, 1951, pp. 95–96)

Piaget's analyses of how children meet and solve basic problems in science provide some specific insights into how to place more emphasis in instruction on the concrete, qualitative aspects of thinking as a prerequisite to formal, quantitative thinking in science.

The study described in this paper was based in Inhelder and Piaget's (1968) investigation and analysis of child thought concerning the effects of certain variable factors on the rate of oscillation of a pendulum. The goals of the study were:

(a) to derive an ordered sequence of instructional objectives on the oscillation of a pendulum from Piaget's analysis of child thought on the topic;
(b) to develop a set of self-instructional materials on the derived objectives; and
(c) To determine the effect of the Piaget-based materials on ninth-grade physical science students' achievement of the derived objectives.

THE PENDULUM PROBLEM

In their investigation of child thought on the pendulum, Inhelder and Piaget (1958) presented children with the problem of determining how four different variables affect the rate of oscillation of a pendulum. The four variables were: (1) the length of the pendulum string; (2) the height of the starting point or angle of swing; (3) the weight of the pendulum bob; and (4) the size of the initial push the child gave to the swinging weight. Within certain limits, only length has an effect on the rate of swing.

Inhelder and Piaget showed that a child progresses through a number of rather well defined stages in the development of his understanding of the relationships involved in the pendulum problem. A summary of their findings follows.

Stage I (Ages 6–7 years*)

The Stage I child (preoperational) cannot give an objective account of the problem of what variables effect the pendulum's swing. His thoughts are dominated by his physical actions. He has difficulty separating his own actions from external factors and constantly interferes with the free motion of the pendulum.

Stage II (Ages 8–10)

The Stage II subject (concrete operational) is able to order the lengths, weights, angles, and pushes serially and to observe the differences between observed frequencies objectively. But he does not manage to exclude the inoperant variables except for the push. The child at this stage does discover the inverse relationship between the length and the frequency. However, he does not yet know how to isolate variables through controlled experiments, and thus concludes that length is not the only relevant variable.

Piaget presents protocols as evidence that Stage II children still make a very fundamental logical error. The children in experimenting varied both the weight and the length at the same time and observed a concomitant change in the frequency. Mistakenly, they concluded that they had proved that either weight or length could independently cause the frequency to change.

Substage III-A (Ages 11-13)

Piaget's Substage III-A is characterized by beginning formal operational thought. The subject at this substage is able to separate out factors as relevant or irrelevant when he is *given* combinations in which one of the factors is varied while the others remained constant. In these cases he reasons correctly and does not make the type of error described for the Stage II subject. However, the Substage III-A subject does not yet know how to produce such combinations on his own in any systematic way.

Substage III-B (Ages 14-15)

The Substage III-B subject is able to exclude both angle and weight and to isolate length as the single variable relevant to the frequency of the pendulum. He does this through a logical procedure, initiated by himself, of varying a single factor while holding the others constant. This is made possible, according to Piaget, because the subjects have available a complex combinatorial system of logic.

The combinatorial system involves, in essence, the ability to logically interpret data involving all possible combinations of experimentation with several variables. Thus the subjects are able to vary length while holding weight and angle constant, to vary angle while holding weight and length constant, and to vary weight while holding length and angle constant, and the adolescent at this substage can arrive at valid conclusions from his experimentation.

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* The age ranges given are approximations drawn from the protocols reported by Inhelder and Piaget (1958).

DEVELOPMENT OF AN INSTRUCTIONAL SEQUENCE ON THE PENDULUM

An instructional sequence based on Inhelder and Piaget's analysis was developed for the pendulum problem. The Piaget-based instructional sequence consisted of a series of self-instructional problems that require the students to experiment with a pendulum apparatus, to systematically exclude weight and angle as factors affecting the period of oscillation, and to determine that the period of a pendulum depends on its length. A more complete description may be found in the original report of the study (Bass, 1968).

Piaget does not carry his analysis of child logic to the point where subjects work with a mathematical equation that summarizes observed relationships. The instructional sequence, however, contained a section which attempted to lead students to comprehend that the length (L) and period (T) data could be coordinated through the equation $L/T^2 =$ constant.

The objectives for the instructional sequence on the pendulum problem are presented in Table I.

TABLE I

Instructional Objectives Derived from Piaget's Analysis of the Pendulum Problem

Piaget's Substage	Derived Objective
II	1. State and apply the rule that a change in the length of a pendulum results in a change in the period.
II	2. State and apply the rule that increasing the length of a pendulum leads to an increase in the period.
III–A, III–B	3. State and apply the rule that a change in the pendulum weight does not affect the period of oscillation.
III–A, III–B	4. State and apply the rule that a change in the angle of oscillation does not affect the period of a pendulum.
above III–B	5. Apply the equation to coordinate numerical data on variation of the period of a pendulum with its length.

EVALUATION OF THE PENDULUM INSTRUCTIONAL MATERIALS

The effects of the instructional sequence on the pendulum were explored through classroom trials with 133 ninth-grade physical science students. Most of the students were either 14 or 15 years of age. The students were well above average in intelligence (median IQ = 115), reading achievement (median =

82nd percentile), and arithmetic achievement (median 73rd percentile). Most of the students completed the instructional sequence in their two or three fifty minute class periods.

Data on pupil achievement were collected through the use of a pretest and a posttest base on the stated objectives and through analysis of the student's responses on the self-instructional materials. The K-R 20 reliability of the test, which also included a section on the balance and inclined plane (Bass and Montague, 1972) was 0.76. Data on the students' achievement of the pendulum sequence objectives are presented in Table II.

TABLE II

Percent of Students Attaining Each Objective on the Pendulum Problem Pretests and Posttests

Objective (See Table I)	Substage	Pretest	Posttest
1	II	87%	89%
2	II	74%	75%
3	III–A, III–B	10%	79%
4	III–A, III–B	8%	62%
5	III–B+	15%	20%

A major gain in the pupil achievement came only with objectives 3 and 4, which involved excluding the weight and angle as factors affecting the period of oscillation. Most of the students knew before instruction that the length of the pendulum had an effect on its period (objective 1) and that an increase in length would lead to an increase in the period (objective 2). There was negligible gain after instruction in the achievement of these two objectives.

Only about 15% of the students on the pretest and 20% on the posttest achieved objective 5. Despite the careful attention to sequencing and the time devoted to qualitative reasoning, the Piaget-based instructional sequence on the pendulum was not successful in leading the ninth grade students to understand and use the rule that the square of the period is proportional to the length of the pendulum (objective 5). Interestingly, the erroneous notion that period and length were directly proportional was widespread on both the pretest and the posttest.

CONCLUSIONS

The science teacher's experience as well as Piaget's careful investigation of the growth of child logic suggest that there are qualitative aspects of problems in physical science that are prerequisite to the comprehension of quantitative laws and relationships. Piaget's analyses are good sources for drawing suggestions about instruction on the qualitative aspects.

Piaget has not investigated the growth of child logic to the point where mathematical equations are used to summarize relationships and solve problems in prediction and control. It was at this point that the instructional materials of this study were unsuccessful. Further studies in the Piagetian vein are desirable to find out how students move from an understanding of relationships at a formal operational level to using equations to express the relationships.

Even though the instructional sequence on the pendulum was carefully designed, 80% of the students in the try out did not learn to apply the pendulum equation. When one considers that the sample of students were well above average academically, the difficulty that ninth graders must have in learning mathematical relationships in science becomes apparent. Might it be that the ability to reason abstractly with equations that describe physical situations is a type of reasoning that is open primarily only to older students at higher grade levels? What experiences at earlier grades will enhance readiness to do quantitative thinking? What are the characteristics of the small percentage of the students who were successful with the quantitative reasoning? These are important questions for the curriculum developer and merit more detailed study.

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THE DEVELOPMENT OF AN INSTRUMENT TO MEASURE UNDERSTANDING OF RELATIONSHIPS BETWEEN SCIENCE, TECHNOLOGY, AND SOCIETY

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INTRODUCTION

The *Opinion Inventory on Relationships Between Science, Technology, and Society* is an instrument designed to measure student understanding of the role of science and technology in society. The instrument is similar in format and content to the *Test on the Social Aspects of Science* (Korth, 1968) and is based upon an abridged version of Korth's "Model of the Social Aspects of Science" (Korth, 1968).

The instrument consists of three parts and contains a total of forty-three items. Students are asked to respond to each of the statements by indicating agreement, uncertainty, or disagreement. The instrument is scored on the basis of one point for each response which corresponds to the response derived from the abridged version of the model. Four scores, a total score and one for each of the three parts, are obtained from the administration of the opinion inventory.

DEVELOPMENT OF THE INSTRUMENT

Three general guidelines were followed in the construction and selection of items to be included in the opinion inventory:

(1) The item had to pertain to one or more statements in the abridged version of Korth's model.
(2) The item could not pertain to any singular incident or to any particular branch of science.
(3) The item should be a statement which is generally accepted as true or false.

Thirty-nine items were generated for the preliminary form of the instrument. Twelve of the items pertained to the interaction of science, technology, and society (Part I), eighteen to science as a social institution (Part II), and nine to the social consequences of science and technology (Part III). These items were submitted to five judges who were asked to rate the items for reflection of the model and for clarity. In addition, each judge was asked to indicate agreement or disagreement with the expected response to each item. One of the items in Part I and two of the items in Part II were found to be unsatisfactory and were discarded. The remaining thirty-six items were incorporated into the preliminary form of the opinion inventory.

In administering the instrument, four teachers in four different high schools administered the instrument to the students in their chemistry classes. A total of 138 students in nine chemistry classes completed the instrument. An alpha coefficient, as a measure of internal consistency (Veldman, 1967), was determined for the total instrument and for each of its three parts. The coefficient for the total instrument was .70, and Parts I, II, and III had coefficients of .52, .48, and .35 respectively.

Ten additional items were then written and the judges found them to be satisfactory. These were added to the instrument while three items which at least ninety-six percent of the students answered correctly were discarded, thus making a total of forty-three statements in the revised form of the instrument.

The revised instrument was administered to eighty-two high school chemistry students and the scoring procedure and the statistical analysis which was employed for the first form of the instrument was repeated. The alpha coefficients, which are presented in Table I along with the means and standard deviations, were .78 for the total instrument and .73, .41, and .57 for Parts I, II, and III respectively.

TABLE 1

Results of the Administration of the Opinion Inventory on Relationships Between Science, Technology, and Society

	Part I	Part II	Part III	Total
Number of Items	15	20	8	43
Mean	11.24	10.46	5.26	26.96
Standard Deviation	2.69	2.33	1.85	5.50
Alpha Coefficient	.73	.41	.57	.78

Table 2 contains the results of the item analysis for the administration of the final form of the instrument. Table 2 is followed by a copy of the instrument. The point-biserial correlations for some items is rather low, indicating a need for further revision. Certain limitations on the author prevented revision at this time. The instrument is presented, however, as a useful intermediate step for those who may be interested in developing similar instruments.

TABLE 2

Results of the Administration of the Opinion Inventory on Relationships Between Science, Technology, and Society With 82 High School Chemistry Students

Item	Key[1]	Scale[2]	Choice Distribution			Mean	Sigma	R(T)[3]	R(S)[4]
			A	U	D				
1.	A	3	57	11	14	.70	.460	.145	.292
2.	D	2	14	19	49	.60	.490	.311	.281
3.	D	1	8	4	70	.85	.353	.192	.345
4.	A	2	58	15	9	.71	.455	.166	.381
5.	A	2	65	8	8	.79	.405	.199	.166

Table 2 (continued)

Item	Key[1]	Scale[2]	Choice Distribution			Mean	Sigma	R(T)[3]	R(S)[4]
			A	U	D				
6.	D	2	0	1	81	.99	.110	.181	.070
7.	A	2	65	12	5	.79	.405	.369	.386
8.	D	1	4	10	68	.83	.376	.451	.571
9.	D	2	37	20	25	.30	.460	.308	.369
10.	A	1	72	10	0	.88	.327	.458	.477
11.	A	2	22	29	31	.27	.443	.024	.341
12.	D	1	5	8	69	.84	.365	.489	.573
13.	A	3	40	19	23	.49	.500	.317	.365
14.	A	1	73	8	1	.89	.313	.359	.395
15.	A	2	55	18	9	.67	.470	.198	.273
16.	D	3	13	16	53	.65	.478	.617	.612
17.	D	2	17	19	46	.56	.496	.472	.524
18.	A	1	57	21	4	.70	.460	.193	.287
19.	D	2	3	2	77	.94	.239	.267	.138
20.	D	1	8	22	52	.63	.482	.529	.606
21.	A	1	33	14	35	.40	.490	.168	.349
22.	D	2	44	22	16	.20	.396	.305	.351
23.	A	1	78	2	2	.95	.215	.204	.315
24.	D	3	6	11	64	.78	.414	.312	.487
25.	D	2	0	0	82	1.00	.000	.000	.000
26.	A	1	60	16	6	.73	.443	.466	.556
27.	D	3	12	16	54	.66	.474	.397	.696
28.	D	2	10	8	64	.78	.414	.484	.371
29.	D	3	15	23	44	.54	.499	.438	.551
30.	A	1	74	7	1	.90	.297	.409	.427
31.	A	2	39	27	16	.48	.499	.046	.167
32.	D	2	43	18	21	.26	.436	.182	.267
33.	D	1	2	20	60	.73	.443	.521	.505
34.	D	1	14	23	45	.55	.498	.257	.292
35.	D	3	7	13	62	.76	.429	.353	.507
36.	A	2	11	26	45	.13	.341	.198	.244
37.	A	2	16	26	40	.29	.396	.003	.285
38.	D	1	25	35	22	.27	.443	.529	.539
39.	A	2	24	30	28	.29	.455	.243	.275
40.	A	1	78	3	0	.95	.215	.410	.442
41.	D	2	45	26	9	.11	.313	.123	.182
42.	A	1	44	31	6	.54	.499	.563	.594
43.	A	3	57	16	8	.70	.460	.415	.478

[1] D–Disagree
A–Agree

[2] Scale 1– Interactions of Science, Technology, and Society
Scale 2– Science As a Social Institution
Scale 3– Social Consequences of Science and Technology

[3] R(T) = point-biserial correlation of item to total

[4] R(S) = point-biserial correlation of item to scale

OPINION INVENTORY ON
RELATIONSHIPS BETWEEN SCIENCE, TECHNOLOGY, AND SOCIETY

You will be allowed 35 minutes to complete the inventory. You should be able to finish in the time allowed, but do not spend too much time on any one item.

The inventory contains statements about science, technology, and society. To the left of each statement are the letters A, U, and D. Below each letter are two lines. Blacken the space between the two lines under

A if you *agree* with the statement
U if you are *uncertain* about the statement
D if you *disagree* with the statement

Mark your answers with pencil and be sure to erase the first mark completely if you change your answer. Answer every statement and be sure that you give only one answer to each statement.

It may be helpful if you try an example before you begin the inventory. Presented below is a sample statement. Applying the above directions, give your reaction to this statement.

EXAMPLE:

A U D All the scientists in the world live in the United States.
☐ ☐ ☐

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO BEGIN THE INVENTORY.

OPINION INVENTORY ON
RELATIONSHIPS BETWEEN SCIENCE, TECHNOLOGY, AND SOCIETY

A U D
☐ ☐ ☐ 1. It is extremely difficult to predict how new scientific knowledge will effect society.

A U D
☐ ☐ ☐ 2. Most scientists are reluctant to share their findings with foreigners because of the danger of exposing secret scientific information.

A U D
☐ ☐ ☐ 3. If all basic research were brought to a halt, future technological activity would not be effected.

A U D
☐ ☐ ☐ 4. Scientists are expected to doubt their own findings as well as those of other scientists.

A U D
☐ ☐ ☐ 5. The aim of scientists is to increase man's knowledge of the physical and biological world.

A U D
☐ ☐ ☐ 6. Once a famous scientist has announced a new discovery, other scientists accept his findings without question.

A U D
☐ ☐ ☐ 7. A free flow of scientific information among scientists is important to scientific progress.

A U D
☐ ☐ ☐ 8. Scientific and technological advances have had little effect upon political relationships between countries.

A U D
|| || || 9. A fundamental rule for scientists is that their discoveries should have some practical use.

A U D
|| || || 10. Scientific research is often necessary to answer questions raised by advances in technology.

A U D
|| || || 11. Scientists are usually concerned that they be given credit for their discoveries.

A U D
|| || || 12. The economic conditions within a nation have little effect upon the amount of scientific research done by the scientists of that nation.

A U D
|| || || 13. A scientist generally has little control over the use society may make of his discovery.

A U D
|| || || 14. Scientists often provide the knowledge which makes new technological advances possible.

A U D
|| || || 15. A scientist is expected to share his knowledge with other scientists rather than to use it exclusively for his own profit.

A U D
|| || || 16. Technology has provided many improvements in living conditions and the public should accept all technological advances as beneficial to social progress.

A U D
|| || || 17. The greatest accomplishments of scientists consist of the many useful commercial products they have produced.

A U D
|| || || 18. Many scientific advances have been made possible only after technologists have provided the tools and equipment for scientists to use in their investigations.

A U D
|| || || 19. Scientific knowledge is of value only to scientists and technologists and not to the general public.

A U D
|| || || 20. Science and technology have been isolated from politics in the past, and it is likely that they will continue to be isolated from politics.

A U D
|| || || 21. One of the reasons that scientists report the results of their investigations is to receive credit for their discoveries.

A U D
|| || || 22. Scientists consistently follow, step by step, a definite procedure called the scientific method.

A U D
|| || || 23. Science and technology are related because advances in one often lead to advances in the other.

A U D
|| || || 24. The uses that can be made of a scientific discovery can usually be determined immediately after the discovery is made.

A U D
|| || || 25. Since scientists in different countries speak different languages, scientists are interested only in the scientific work done in their own country.

A U D
|| || || 26. The political climate of a nation may affect the problems investigated by its research scientists.

A U D
|| || || 27. Many of the problems in the world today are the sole responsibility of scientists since they have developed the knowledge which has contributed to the development of nuclear weapons, air pollution, etc.

A U D
|| || || 28. Science is primarily a method for inventing new devices.

A U D
|| || || 29. The scientist who makes a particular discovery is the one best qualified to determine what use society should make of his discovery.

A U D
|| || || 30. Scientific and technological advances often lead to changes in the economic structure of society.

A U D
|| || || 31. The persons best qualified to judge the contributions of one scientist to scientific progress are other scientists.

A U D
|| || || 32. The principal aim of scientists is to provide the people of the world with improved living conditions.

A U D
|| || || 33. The social problems caused by scientific and technological advances are usually so minor that they are of little consequence to society.

A U D
|| || || 34. Scientists depend upon engineers and other technologists to provide them with laws and theories.

A U D
|| || || 35. Scientists should plan and direct their research only to problems which presently confront society.

A U D
|| || || 36. Scientists are more interested in the explanation of events than in the collection of facts.

A U D
|| || || 37. A scientist is usually interested in gaining recognition from other scientists.

A U D
|| || || 38. Technologists generate the knowledge and explanations which scientists use to invent new products.

A U D
☐ ☐ ☐ 39. The theories of science are not likely to endure in their present form.

A U D
☐ ☐ ☐ 40. The needs of a society at a given time may influence the kinds of questions its scientists will investigate.

A U D
☐ ☐ ☐ 41. Technology is a specialized branch of science dealing with mechanical objects.

A U D
☐ ☐ ☐ 42. New legislation is often necessary to control problems created by scientific and technological advances.

A U D
☐ ☐ ☐ 43. The applications of basic scientific knowledge cannot be decided on the basis of scientific evidence alone.

References

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AN EVALUATION OF SUPPLEMENTARY CHEMISTRY CURRICULUM MATERIALS REFLECTING RELATIONSHIPS BETWEEN SCIENCE, TECHNOLOGY, AND SOCIETY

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INTRODUCTION

The purpose of this study was to develop and evaluate supplementary chemistry curriculum materials reflecting relationships between science, technology, and society. The first phase of the study involved the development of the curriculum materials; this was followed by the development of an evaluative instrument. In the final phase of the study the curriculum materials were evaluated for their effectiveness in promoting student understanding of relationships between science, technology, and society.

DESCRIPTION OF THE CURRICULUM MATERIALS

The curriculum materials are presented in the form of a two-week instructional unit and consist of a student booklet, *Nuclear Energy: Origins and Consequences*, and a teacher's manual, *Teacher's Guide to Nuclear Energy: Origins and Consequences.*

The student booklet contains an introduction, a section on science and technology, and three episodes, each of which describes a major scientific discovery and some of the social consequences of the applications of this discovery. The first episode pertains to X-rays, the second to radioactivity, and the third to nuclear fission. In addition, the student booklet contains six exercises which are to be completed by the students at the appropriate time in the presentation of the unit.

The teacher's guide contains suggestions for using the curriculum materials as well as the instructional sequence prescribed for the teaching of the unit. The unit is divided into ten lessons, with each lesson containing a suggested procedure as well as a list of possible answers for the various questions and activities.

THE EVALUATION OF THE CURRICULUM MATERIALS

VARIABLES

In evaluating the effectiveness of the materials, the use of the curriculum materials was the independent variable controlled by randomly assigning classes to either the experimental or the control group. Since it was believed that the mental ability of the students might be a major factor influencing the effectiveness of the materials, this variable was taken into consideration in analyzing the results of the evaluation.

The individual teachers who participated in the experimental tryout of the instructional materials also represented a major variable, and the selection of teachers automatically introduced other associated variables, such as the students' prior experiences in chemistry class, the characteristics of the school, and the socio-economic class of the students. The teacher variable was taken into consideration in the statistical analysis, and the associated variables were considered to be controlled by having the same teacher teach both an experimental and a control class.

The major dependent variable of the evaluation was student understanding of relationships between science, technology, and society. This variable was considered to be composed of three different, but related parts: understanding of (1) the interaction of science, technology, and society, (2) science as a social institution, and (3) the social consequences of science and technology.

THE SAMPLE

The experimental tryout and evaluation of the curriculum materials was conducted in five high schools located in five different school districts. Three of the schools were located in Texas and two of them were located in Kentucky. The schools ranged in size from 400 students to 1,550 students, and one chemistry teacher from each school participated in the study.

Two chemistry classes of each teacher were used in the evaluation. One class for each teacher was randomly assigned to the experimental group; a second class for the same teacher was assigned to the control group. The experimental group consisted of ninety-three students in five chemistry classes while the control group consisted of one hundred ten students in five chemistry classes.

INSTRUMENTS

The major dependent variable under consideration was student understanding of relationships between science, technology, and society. The instrument used to measure this variable was the *Opinion Inventory on Relationships Between Science, Technology, and Society*. The alpha coefficient, as a measure of internal consistency (Veldman, 1967), for the total instrument was determined to be .78 while Parts I, II, and III had coefficients of .73, .41, and .57 respectively. Four scores are obtained from the administration of the instrument; a total score and a score for each of its three parts.

Student scores on the standardized intelligence test used by their school district were obtained from the school records. The instruments used by the school districts included the California Test of Mental Maturity, the Lorge-Thorndike Intelligence Test, the Otis Quick-Scoring Mental Ability Test, and the SRA Tests of Educational Ability.

EXPERIMENTAL DESIGN

The posttest-only control group design, as described by Campbell and Stanley (1963), was adopted for the purpose of evaluating the curriculum materials. This design controls for factors jeopardizing internal validity since it can be assumed that history, maturation, and other contaminating variables will affect the experimental and control groups similarly. The experimental group does not receive a pretest, and this eliminates the possibility of pretest-treatment interaction. In addition, the use of a pretest would have introduced the possibility of an interaction between the teachers' knowledge of the test and the way in which they presented the materials.

PROCEDURE

Each of the five teachers participating in the study was asked to teach the instructional unit *Nuclear Energy: Origins and Consequences* for a two-week period between April and the end of the school year. Individual teachers were permitted to select the time period which best fitted their schedules.

The teachers were asked to proceed with the regularly-scheduled instruction for the control class. The teachers were given no directions for the experimental class other than to try to follow the specified instructional sequence as closely as possible. Immediately following the completion of the instructional unit by the experimental class, the teacher administered the evaluative instrument to both the experimental class and the control class.

STATISTICAL ANALYSES

The general purpose of the evaluation was to determine if the classroom use of the curriculum materials effected students' understanding of relationships between science, technology, and society. Hypothesis 1 related to this purpose is:

> Students who have been presented the instructional unit *Nuclear Energy: Origins and Consequences* do not have a significantly greater understanding of relationships between science, technology, and society than students who have not been presented the instructional unit.

The subhypotheses subsumed under the hypothesis involved student understanding as measured by:

A. The total evaluative instrument;
B. Part I of the evaluative instrument, which pertains to the interactions of science, technology, and society;
C. Part II of the evaluative instrument, which is concerned with science as a social institution;
D. Part III of the evaluative instrument, which pertains to the social consequences of science and technology.

A separate analysis was performed to test each of the four subhypotheses. Since the same teacher taught one experimental class and one control class, the teacher effect was taken into consideration by adopting a 2 x 5 analysis of variance design in which subjects were stratified according to two levels of treatment and five levels of teacher.

In order to determine if the effectiveness of the curriculum materials was dependent upon the level of mental ability of the students receiving instruction, the students in each class were assigned to one of three subgroups on the basis of their scores on the standardized intelligence test used by their school district and their rank on this test in relation to other members of the same class. A total of twelve analyses, one for each of the three subgroups on each of the four scales of the evaluative instrument, were performed with the use of a single-classification analysis of variance design to test Hypothesis 2:

> The scores of the students of a particular subgroup of the experimental group are not significantly greater than the scores of the students of the corresponding subgroup of the control group.

RESULTS OF THE EVALUATION

Hypothesis 1

The first analysis related to Hypothesis 1 was performed to test the hypothesis as it pertained to understanding as indicated by students' total scores on the evaluative instrument, and the results of this analysis are presented in Table 1.

For the total scores on the evaluative instrument, the main effect of treatment produced a difference in favor of the experimental group significant at the .01 level. The main effect of teacher was also significant at the .01 level, but the interaction of main effects was not significant.

The second analysis was performed with the scores on Part I of the evaluative instrument, and the results reveal that the main effects of treatment and teacher each produced significant differences at the .05 level. Once again, the difference between treatments was in favor of the experimental group, and once again the interaction of main effects was not significant. The results of this analysis are presented in Table 2.

TABLE 1

Analysis of Students' Total Scores on the Opinion Inventory on Relationships Between Science, Technology, and Society

A. Analysis of Variance Table

Source	D.F.	Mean Square	F-Ratio	Probability
Treatment (A)	1	170.097	7.7327	.0061
Teacher (B)	4	177.502	8.0693	.0000
A x B Interaction	4	31.475	1.4309	.1180
Within	193	21.997		
Total	202	25.997		

B. Means for All Effects

	Teacher					Treatment
	1	2	3	4	5	Averages
Exp.	28.5625	28.6842	30.8750	30.7500	34.2222	30.6188
Control	25.2381	29.6400	27.9565	29.6250	31.3529	28.7625
Teacher Averages	26.9003	29.1621	29.4185	30.1875	32.7876	

TABLE 2

Analyses of Students' Scores on Part I of the Opinion Inventory on Relationships Between Science, Technology, and Society

A. Analysis of Variance Table

Source	D.F.	Mean Square	F-Ratio	Probability
Treatment (A)	1	25.653	5.0991	.0235
Teacher (B)	4	16.938	3.3667	.0110
A x B Interaction	4	4.341	.8628	.5107
Within	193	5.031		
Total	202	5.355		

B. Means for All Effects

	Teacher					Treatment
	1	2	3	4	5	Averages
Exp.	11.5625	12.7368	12.8750	12.2083	13.6111	12.5988
Control	10.8095	12.1200	11.5652	12.5417	12.3529	11.8779
Teacher Averages	11.1860	12.4284	12.2201	12.3750	12.9820	

The next analysis of this series concerned the scores for Part II of the evaluative instrument, and the results of this analysis are presented in Table 3. Once again, both the main effects of treatment and teacher were significant—the former at the .05 level and the latter at the 0.1 level. The interaction of the main effects was also significant at the .01 level, thus indicating that, for the understanding measured by this scale of the instrument, the treatment did not work equally well for all teachers.

TABLE 3

Analyses of Students' Scores on Part II of the Opinion Inventory on Relationships Between Science, Technology, and Society

A. Analysis of Variance Table

Source	D.F.	Mean Square	F-Ratio	Probability
Treatment (A)	1	26.502	5.0928	.0236
Teacher (B)	4	43.548	8.3683	.0000
A x B Interaction	4	20.995	4.0344	.0040
Within	193	5.204		
Total	202	6.381		

B. Means for All Effects

	Teacher					Treatment
	1	2	3	4	5	Averages
Exp.	11.7500	10.0526	12.0625	12.1667	14.0000	12.0064
Control	9.9048	11.8800	10.8261	10.8750	12.8824	11.2736
Teacher Averages	10.8274	10.9663	11.4443	11.5208	13.4412	

The final analysis related to Hypothesis 1 concerned understanding as measured by Part III of the opinion inventory. The results of this analysis, which are presented in Table 4, indicate that the teacher effect was significant at the .01 level and that neither the treatment effect nor the interaction of main effects was significant.

TABLE 4

Analyses of Students' Scores on Part III of the Opinion Inventory on Relationships Between Science, Technology, and Society

A. Analysis of Variance Table

Source	D.F.	Mean Square	F-Ratio	Probability
Treatment (A)	1	8.004	3.0650	.0778
Teacher (B)	4	13.789	5.2802	.0007
A x B Interaction	4	.472	.1809	.9459
Within	193	2.611		
Total	202	2.817		

B. Means for All Effects

	Teacher					Treatment
	1	2	3	4	5	Averages
Exp.	5.2500	5.8947	5.9375	6.3750	6.6111	6.0137
Control	4.5238	5.6400	5.5652	6.2083	6.1176	5.6110
Teacher Averages	4.8869	5.7674	5.7514	6.2917	6.3644	

On the basis of the above results, Hypothesis 1 was rejected as it related to understanding as measured by the total evaluative instrument and Parts I and II of the instrument.

Hypothesis 2

Hypothesis 2 was tested by comparing the subgroups of the experimental and control groups with the use of a single-classification analysis of variance design.

The means for each of the subgroups of the experimental and control groups, and for each of the four analyses, are presented in Table 5. A comparison of the means of corresponding subgroups reveals that for all subgroups except the "low" on Part I of the instrument, the experimental group obtained a higher mean than the control group.

The results of the analysis of variance, which are presented in Table 6, reveal that only the differences between the "medium" subgroups of the experimental and control groups were significant. For these subgroups, the experimental group had significantly higher scores, at the .01 level, on Part I of the instrument and at the .05 level on the total instrument. The differences between the scores of the two subgroups on Parts II and III of the instrument, while not significant, approached significance. In only one other comparison, that of the "high" subgroups for Part I of the instrument, did the difference approach significance.

Hypothesis 2 was rejected as it pertained to the "medium" subgroups and the scores on the total evaluative instrument and Part I of the instrument, but it was accepted for all other comparisons.

TABLE 5

Means of the Scale Scores for the Experimental and Control Level-of-Mental-Ability Subgroups

Scale	Subgroup	N_{Exp}	$Mean_{Exp}$	N_{Con}	$Mean_{Con}$
Part I	Low	25	11.8400	25	11.9200
	Medium	23	13.0870	26	11.6923
	High	23	13.6957	28	12.7500
Part II	Low	25	11.2000	25	10.7200
	Medium	23	12.4783	26	11.2692
	High	23	12.6957	28	12.5714
Part III	Low	25	5.7200	25	5.5200
	Medium	23	6.3478	26	5.5385
	High	23	6.6087	28	6.3929
Total	Low	25	28.7600	25	28.1600
	Medium	23	31.9130	26	28.5000
	High	23	33.0000	28	31.7143

TABLE 6

Analysis of Variance Table for the Scale Scores of the Experimental and Control Level-of-Mental-Ability Subgroups

A. Low Experimental and Low Control

Scale	MS_{bg} D.F.=1	MS_w D.F.=49	MS_t D.F.=50	F-Ratio	Probability
Part I	.0800	6.4417	6.3118	.012	.9079
Part II	2.8800	7.8133	7.7127	.369	.5536
Part III	.5000	3.0683	3.0159	.163	.6908
Total	4.5000	26.7483	26.2943	.168	.6863

B. Medium Experimental and Medium Control

Scale	MS_{bg} D.F.=1	MS_w D.F.=47	MS_t D.F.=49	F-Ratio	Probability
Part I	23.7375	3.3056	3.7313	7.181	.0099
Part II	17.8394	6.1884	6.4311	2.883	.0924
Part III	7.9945	2.6315	2.7432	3.038	.0842
Total	142.1637	20.2197	22.7602	7.031	.0106

C. High Experimental and High Control

Scale	MS_{bg} D.F.=1	MS_w D.F.=49	MS_t D.F.=50	F-Ratio	Probability
Part I	11.2922	3.4718	3.6282	3.253	.0740
Part II	.1949	4.9740	4.8784	.039	.8381
Part III	.5883	1.8808	1.8549	.313	.5852
Total	20.8739	17.0962	17.1718	1.221	.2740

CONCLUSIONS

The following conclusions were made from the results of the evaluation:

1. The classroom use of the instructional unit *Nuclear Energy: Origins and Consequences* resulted in increased student understanding of relationships between science, technology, and society.
2. The use of the curriculum materials was more effective in increasing student understanding of the interactions of science, technology, and society and of science as a social institution than it was in increasing student understanding of the social consequences of science and technology.
3. The teacher variable, which may include a number of associated variables was a more important factor in contributing to student understanding of relationships between science, technology, and society than was the use of the curriculum materials developed in this study.
4. When students in both the experimental and control groups were assigned to high, medium, and low subgroups based on their mental ability, a comparison of the scores of corresponding subgroups indicated that the curriculum materials were most effective with students of the middle range of mental ability.

IMPLICATIONS

One of the conclusions of this study is that the experimental group had a greater understanding of the relationships between science, technology, and society than the control group. While the difference between the mean scores of the two groups was statistically significant, the numerical value of this difference for the total evaluative instrument was less than two points. It therefore appears that the classroom use of the curriculum materials was only moderately successful in affecting student understanding of the relationships under consideration.

The most obvious implication of the above results is that the instructional unit developed in this study is limited in its effectiveness in promoting an understanding of the social implications of science and technology. One of the weaknesses of the curriculum materials may be that many of the relationships reflected by the content of the instructional unit are illustrated only once. Furthermore, many of the relationships are implicit and may not be discerned by a reader who is not already aware of the relationships. If the materials were revised, and if these weaknesses were removed or reduced, the effectiveness of the materials might be increased.

Another weakness of the curriculum materials may lie in the teacher's guide. While behavioral objectives for each lesson are listed in the guide, the objectives generally pertain to the content which illustrates the relationships and not to the relationships themselves. A teacher who is not already aware of the relationships illustrated by the narrative may have difficulty in extracting them from the narrative or from the behavioral objectives. A revised teacher's guide—one in which the relationships are made more explicit—might increase the effectiveness of the curriculum materials.

The results of the study also indicated that students who are taught by different teachers differ significantly in their understanding of relationships between science, technology, and society. In most analyses, the teacher effect was found to be more significant than the treatment effect. One implication of this result is that, while the use of supplementary materials similar to the ones used in this study may provide a means for increasing student understanding of the social implications of science and technology, it may not provide the most effective means for doing so. The expense, energy, and time involved in developing supplementary materials might be better invested in training teachers to more effectively teach relationships between science, technology, and society without the use of special materials.

The use of the curriculum materials was relatively unsuccessful with students of lower mental ability. This introduces the possibility that the format of the materials is one which should be used only with students in the middle or high ranges of mental ability. Another possibility is that the relationships were not sufficiently explicit to be grasped by the students of the "low" subgroup. A revision of the materials in which the format was retained but the relationships were made more explicit might make them more suitable for students in the lower range of mental ability.

While the students of the experimental "high" subgroup indicated the greatest degree of understanding of the relationships under study, the difference between the scores of the experimentai and control "high" subgroups was not significant. This suggests the possibility that the treatment was not as effective with the "high" subgroup as with the "medium" subgroup because the students of higher mental ability were more aware of the relationships before the onset of the experimental treatment and the treatment did not act to produce any significant changes in understandings of the students of the "high" subgroups. It therefore appears that the materials are not particularly suited for students in the high range of mental ability.

While the results of this study are limited to the evaluation of one set of curriculum materials, the above considerations support the possibility that different types of curriculum materials in this area might act differently with students of differing mental abilities. Yet another possibility is that a variety of approaches or materials with different formats might provide the best means for all students in a particular classroom.

RECOMMENDATIONS FOR FURTHER RESEARCH

The scope of this study was limited by restrictions which were imposed upon it by the author. While the evaluation yielded results which suggested answers to some of the questions posed by the study, these results also suggest possibilities for further research in this area.

Only one instructional unit was developed in this study. Other units using a similar approach are needed to determine if the approach is effective in increasing student understanding of the social implications of science and technology. Since the teacher was found to be a major factor in contributing to student understanding of the relationships under study, research related to the characteristics of teachers whose students show a substantial understanding of these relationships might provide insights into methods of training other teachers to acquire these characteristics. Finally, there remains a need for research with other methods and a need for the development of curriculum materials employing approaches and techniques that are different from those used in this study but which attempt to provide high school students with an opportunity to increase their understanding of the role of science and technology in society.

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THE DEVELOPMENT OF A SCALE TO ASSESS COLLEGE STUDENTS' ATTITUDES TOWARD NUCLEAR SCIENCE

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INTRODUCTION

It has been suggested by some researchers that the adverse opinions some students express about science might be influenced by the role of scientists in the development of nuclear weapons. This suggestion seems plausible when one considers the unfavorable publicity about radioactivity and nuclear energy that has been generated by certain scientists, politicians, and writers. On the other hand, the Atomic Energy Commission and other proponents have appealed strongly to the public on behalf of a nuclear industry in the United States by optimistically describing its potential benefits and offering assurances that it poses little danger to the welfare of humanity. In light of the dichotomous nature of this controversy, a basic question that might be raised is, "What attitudes do college students hold toward nuclear science as a controversial and evolving field of technological application?"

Since no instruments were in existence to assess such attitudes, for this study it was necessary that the investigator develop an *Attitude Toward Radioactivity Scale* (ATRS) to achieve this purpose.

MODEL OF AN ATTITUDE

Since the purpose of the study was to assess what attitudes college students hold toward nuclear science, it would be useful at this point to define what was meant by the construct "attitude" as used throughout the study. Rokeach (1970) offers this definition: "An attitude is a relatively enduring organization of beliefs around an object or situation predisposing one to respond in some preferential manner."

When using the term belief, Rokeach means any simple proposition, conscious or unconscious, that can be inferred from what a person says or does and can be preceded by the phrase "I believe that . . . ." The belief expressed by a subject might describe the object of the belief as true or false; evaluate it as good or bad; or advocate a certain course of action as desirable or undesirable. As pointed out by Fishbein (1967), most attitude measurement instruments (including the Likert-type summated rating scale described here) obtain individual attitude scores by considering the beliefs expressed by the respondant toward the attitude object.

Each belief within an attitude organization can be considered to have three components.

1. A cognitive component representing a person's knowledge, held with varying degrees of certitide, about what is true or false, good or bad, desirable or undesirable.

2. An effective component capable of arousing affect of varying intensity about the belief when its validity is seriously questioned, as in an argument.
3. A behavioral component which leads to some action when the belief is suitably activated.

Concurring with this analysis are Rosenberg and Hovland (1960) who used slightly different terminology to state, "when attitudes are studied, what are observed are the evoking stimuli on the one hand and the various types of response on the other. The types of response that are commonly used as indices of attitudes fall into three major categories: cognitive, affective, and behavioral."

Harding, et.al. (1954) pointed out that the relationship among these components is so close that it makes little difference which ones are used to rank individuals with respect to their attitudes toward specific stimuli, e.g., ethnic groups. Thus, when Rosenberg (1960) investigated the cognitive component as a function of the affective, he hypothesized that a strong positive affect toward an object should be associated with beliefs that it leads to the attainment of a number of values important to the subject. For example, Rosenberg would agree that an individual who believes that nuclear science will ultimately provide mankind with adequate power resources accompanied by low levels of pollution or will yield improved techniques in medicine will have a favorable attitude toward that field. Conversely, an individual who fears nuclear science as a source of explosives and radioactive contamination of the environment will hold an unfavorable attitude.

DEVELOPMENT OF THE INSTRUMENT

The model of an attitude developed above suggests that in defining an individual's attitude toward an object or situation, some procedure should be used to sample his beliefs about representative aspects of the attitude object.

One technique of sampling a person's beliefs about specific components of an attitude object is the method of summated ratings first reported in a monograph by Likert (1932). In this method of attitude scaling, the subject is presented with a list of declarative statements about the attitude object. Approximately one-half of the statements refer to the attiude object favorably and the rest are stated unfavorably. The subject is then asked to indicate whether he agrees strongly, agrees somewhat, is neutral, disagrees somewhat, or disagrees strongly with each of the statements. If he agrees strongly with a favorable statement he receives a weighted mark of four for his belief about that statement. If he agrees somewhat his weighted mark is three, if he is neutral it is two, if he disagrees somewhat it is one, and if he disagrees strongly with a favorable statement his weighted mark on that item is zero. For unfavorable statements the marking system is reversed. The total score of an individual is the summation of the scores he obtained on the individual items and is considered representative of his attitude toward the object or situation.

In determining a person's attitude toward nuclear scinece, then, a list of statements about the nuclear power industry, nuclear medicine, industrial applications of radioactivity, atomic scientists, and the atom's history and future could elicit his beliefs on these topics and yield a quantitative indication of his attitude.

A pool of 42 statements about nuclear science was assembled by the experimenter from both technical and popular sources to form an item pool for use in the *Attitude Toward Radioactivity Scale* (ATRS). The editorial and commentary pages of newspapers, articles in *Science and Public Affairs,* and the Atomic Energy Commission *Understanding the Atom Series* of booklets yielded many of these items. An effort was made to word each statement in such a way that it would sample only one component of a subject's belief concerning the idea expressed in that item. That is, the subject was asked to agree or disagree with a statement that described some aspect of nuclear science as true or false (cognitive), evaluated it as good or bad (affective), or advocated some course of action (behavioral). Items 3, 6, 8, 10, 11, 14, 18, and 19 in the final form of the *Attitude Toward Radioactivity Scale* (ATRS) were intended to sample the cognitive components of a subject's beliefs. Items 1, 5, 9, 16, 17, and 20 were included to sample the affective component, and items 2, 4, 7, 12, 13, and 15 were meant to elicit behavioral components of the beliefs held by college students about various aspects of nuclear science.

The original 42 items were submitted as a trial run to 125 University of Texas students in seven intact classes during December, 1971, to simulate as closely as possible the procedure expected to be followed in the final collection of data. After assigning weighted marks to the responses of all subjects to each item, a summated score was calculated for each student. Two criteria were then utilized to determine which of the original items would constitute the final form of the ATRS.

The first step taken was to ask the opinions of three groups of judges as to which of the items seemed capable of assessing student attitudes. The judges were asked to reach each statement and rate it according to the following directions:

> Please judge each of the statements on the *Attitude Toward Radioactivity Scale* as: (A) the item is capable of effectively assessing a college student's attitude toward radioactivity, or (B) the item more likely measures knowledge of the principles and applications of radioactivity.

The groups of judges were composed of four professors of science education, six graduate students in science education, and four college undergraduates not having science backgrounds. It was felt that these diverse groups would complement one another in judging the ability of each statement to assess attitudes only. It was necessary for an item to receive a majority of votes indicating agreement in at least two of the three judging groups in order to be considered by the second selection criterion. Also, agreement among the three groups of judges on which items would effectively sample attitudes was considered a form of content validity for the ATRS since no other validation procedure is applicable for an attitude scale of this type.

The second step taken in the selection of items was to determine which statements most effectively discriminate between subjects having favorable and unfavorable attitudes toward nuclear science. This was done by comparing the scores on each item of the top and bottom scoring 27% of the subjects ($N = N_H = N_L = 32$) with a t-test. The value of this "t" is a measure of the extent to which a given statement differentiates between the high and low groups. Edwards (1957) suggests a "t" value equal to or greater than 1.75 as indicating that the average responses of the high and low groups to a particular statement differ significantly provided both groups are composed of 25 or more subjects.

When the two criteria described above were applied to the 42 statements submitted as a trial run, twenty of the items were judged appropriate for sampling attitudes and also had t-scores ranging from 1.86 to 10.1. These, then, became the statements which, with some minor rewording, constituted the final form of the *Attitude Toward Radioactivity Scale* (ATRS).

RELIABILITY OF THE ATRS

In discussing the method of summated ratings, Edwards (1957) states that the reliability of the scores on a dichotomous scale can be obtained from a split-halves type of correlation. A procedure that has similarities to correlating two halves of the same test is the method of rational equivalence using the Kuder-Richardson Formula 20. A generalization of this formula is the alpha coefficient of internal consistency developed by Cronbach (1951). Coefficient alpha, which reflects the degree of reliability among all items of a scale, is not restricted in its application to tests composed of dichotomous items, but can be used on a test having a range of scoring as long as the total score is the simple sum of the item scores (as is the case in the method of summated ratings).

Using the responses of 1,157 subjects who responded to all twenty statements, Program TESTAT written by Veldman (1967) computed a coefficient alpha of .83 for the ATRS.

ATTITUDE TOWARD RADIOACTIVITY SCALE

Listed below are twenty statements about radioactivity and nuclear energy and their role in contemporary society. After reading each statement, please indicate the extent to which you agree with the idea it expresses by checking one of the following five responses on the Response Sheet.

A.C. – You agree completely with the statement
T.A. – You tend to agree with the major idea expressed in the statement
N. – You are neutral or undecided about what is expressed in the statement
T.D. – You tend to disagree with the major idea expressed in the statement
D.C. – You disagree completely with the statement

1. To date the development of nuclear energy has proceeded in an orderly and responsible manner which promises to carry over into future development.
2. It would be desirable for all large cities to replace their coal-burning power plants with plants that generate electricity from nuclear energy.
3. We should be suspicious of nuclear powered submarines as major polluters of the world's oceans.
4. The spending of large sums of money for basic nuclear research would be a poor investment by the federal government.
5. The job crisis currently confronting many highly trained nuclear scientists was inevitable because the "product" they produce never was worth the high cost.

6. In general, the national news media tend to present information about nuclear power and radioactivity in an unfavorable light.
7. We should question the construction of all nuclear facilities because of the harmful products they produce.
8. People living near a nuclear reactor can have confidence in the ability of health physicists to prevent major radiation accidents.
9. If forced to make a choice between continuing their research and taking a stand for the public good, most nuclear scientists would give priority to their research.
10. Although radiation can be helpful or harmful, it is safe to say that to date, more lives have been saved than lost by it.
11. People living near a harbor have no cause to be apprehensive when a nuclear powered ship is in port for any length of time.
12. Over the next decade the United States should commit itself to developing a network of nuclear power reactors to meet its future energy demands.
13. Radionuclides should not be allowed in hospitals because of the danger of leakage or contamination.
14. As the number of nuclear power reactors brought into operation in the United States increases, I fear we are likely to detect significantly higher levels of radioactive contaminants in our streams and lakes.
15. We can be optimistic that scientists will soon develop ways of utilizing the high temperature water released from nuclear power plants for some useful purpose.
16. Most nuclear physicists working today have "sold their souls" to the military-industrial complex in order to obtain their research grants.
17. An appropriate adjective that describes the activities of the United States Atomic Energy Commission is "militaristic."
18. Scientists can be depended upon to study nearby fracture zones very carefully before detonating nuclear test explosives underground.
19. Because of the increased use of radioactivity, I fear an increasing genetic load for mutations among humans.
20. We can be optimistic that in the future the benefits derived from radioactivity will exceed any possible misuses of nuclear power.

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THE IDENTIFICATION OF FACTORS ASSOCIATED WITH COLLEGE STUDENTS HOLDING FAVORABLE ATTITUDES TOWARD NUCLEAR SCIENCE

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INTRODUCTION

A frequently stated objective of science instruction is that it should instill favorable attitudes in students toward science and the applications of science. Studies by Mead and Metraux (1957) and Beardslee and O'Dowd (1961) indicated this objective was not being achieved satisfactorily. Allen (1959) suggested that the adverse opinions expressed by some students toward science might be influenced by the well publicized role of scientists in the development of nuclear weapons.

This study utilized an *Attitude Toward Radioactivity Scale* (ATRS) developed by the investigator to measure college students' attitudes toward nuclear science to answer the following question: What are some of the characteristics associated with those college students holding the more favorable attitudes toward nuclear science?

Accumulated evidence lends little support to accepting the value of information as an influence in developing positive attitudes. However, when Greenberg (1964) studied the attitudes held by college students toward fall-out shelters relative to the information made available to them, he concluded that attitude change is consistently related to information gain. Also, data obtained by both Grozier (1969) and Jones (1969) on developing positive science attitudes by college students in physical science courses indicated that the greater a student's knowledge of scientific facts, concepts, and principles, the more positive will be his attitude toward science.

While field testing his instrument to assess high school students' beliefs about science and scientists, Champlin (1970) concluded that an accurate understanding of science is not prerequisite to having a favorable attitude toward science.

THE STUDY

The references cited above indicate that the relationship between a college student's understanding of a field of science and his attitude toward it cannot be predicted with any certainty. Hypothesis H_0 1 expressed in null form stated:

> No relationship exists between the knowledge a college student has about the principles and applications of nuclear science as measured by the *Test on Understanding Radioactivity* (TOUR) and his attitudes toward nuclear science.

This hypothesis was tested by computing a correlation between the scores on the *Attitude Toward Radioactivity Scale* (ATRS) and the *Test on Understanding Radioactivity* (TOUR).

The *Test on Understanding Radioactivity* (TOUR) was developed by the author to discriminate between college students possessing varying knowledge of the principles and applications of nuclear science. The TOUR Test was validated primarily using content and empirical validation procedures. Using a split-halves technique, the reliability of the TOUR Test was ascertained to be .82.

The subject's grade classification has been treated as a variable in numerous studies on attitudes without definitive results. The individual researcher who has perhaps investigated most closely the relationship between a student's grade level and the attitudes and values he professes was Lehmann (1963) who concluded that changes in critical thinking ability, attitudes, and values occur from the student's freshman to senior years in college. Lehmann, however, was unable to specify whether it was the academic or informal experiences of college students that had the greater impact on the changes in attitudes he observed. Hypothesis H_0 2 expressed in null form stated:

> No relationship exists between the grade level of a college student and his attitude toward nuclear science.

This hypothesis was tested by computing an analysis of variance among the ATRS scores of subjects who identified themselves on a Student Descriptor Sheet as freshmen, sophomores, juniors, seniors, or graduate students.

Using college students of the life sciences, physical sciences, social sciences, and the humanities as subjects in a comparative study of student attitudes toward the sciences and humanities as courses of study, Snow and Cohen (1968) detected significant differences in the attitudes expressed by each group. On the other hand, Wilson (1954), while studying the opinions of college students on the nature and purposes of science, reported little difference in the reactions of science majors and non-science majors to the majority of the statements on the instrument he prepared.

Hypothesis H_0 3 expressed in null form stated:

> No relationship exists between the subject major of a college student and his attitude toward nuclear science.

This hypothesis was tested by computing an analysis of variance among the ATRS scores of subjects in fourteen groups of related subject majors who reported their major subjects on a Student Descriptor Sheet completed by each student.

Using large samples of high school seniors to assess student attitudes toward science and scientists, Allen (1959) reported positive relationships between intelligence and favorable attitudes. Guilford (1959) after reviewing several studies of school achievement as a function of measured intelligence, documented a positive correlation between intelligence test scores and school grades. Grade point averages were accessible from the students without asking them to identify themselves by name. Is a student's grade point average, and indirectly his intelligence, a factor in the attitudes he holds toward radioactivity?

Hypothesis H_0 4 expressed in null form stated:

> No relationship exists between a college student's grade point average and his attitude toward nuclear science.

This hypothesis was tested by computing an analysis of variance among the

ATRS scores of subjects who reported their grade point averages as falling within one of five ranges equivalent to C−, C+, B−, B+, and A−.

A major conclusion by Myers (1967) was that no relationship exists between college students' attitudes toward science and their high school backgrounds in science. And in comparing the responses to statements about the nature and purposes of science by sixty subjects who had taken fifteen or more semester hours of science to those of 225 students who took less than fifteen hours of science, Wilson (1954) noted few differences in the attitudes expressed by each group.

Although the evidence cited above is generally negative toward the proposition that science instruction develops positive attitudes toward science in students, the question of whether a student's attitude toward a particular area of science is related to the number of science courses he has taken has not previously been investigated in any detail.

Hypothesis H_0 5 expressed in null form stated:

> No relationship exists between the number of science courses completed in high school by a college student and his attitude toward nuclear science.

This hypothesis was tested by computing an analysis of variance among the ATRS scores of subjects who reported having taken one, two, three, four, or more than four science courses while in high school.

Hypothesis H_0 6 expressed in null form stated:

> No relationship exists between the number of semester hours of college science courses studied by a college student and his attitude toward nuclear science.

A Student Descriptor Sheet prepared by the investigator asked the subjects to indicate within a range the number of semester hours of college science they had studied. Assuming a uniform distribution of science semester hours to exist about the mid-points of each of the ranges, a correlation was computed between the ATRS scores and the midpoints of the ranges of semester hours in college science. For the purpose of this correlation, "more than 100" semester hours was arbitrarily defined 100.

How a college student described himself politically (e.g. liberal vs. conservative) was found to have an effect on the attitudes he expressed toward political, economic, religious, and social issues in a study by Sinai (1951). Whether college students' political leanings can be associated with the attitudes they hold toward specific areas of science such as nuclear science has not been previously investigated.

In this study Hypothesis H_o 7 expressed in null form stated:

> No relationship exists between the self-described political leanings of a college student and the attitudes he holds toward radioactivity.

The Student Descriptor Sheet asked each subject to identify himself as very conservative, conservative, middle of the road, liberal, or radical left in his politics. Because very few of the subjects considered themselves to be "very conservative," those who did were grouped with the conservatives for the purpose of statistical analysis. An analysis of variance among the mean ATRS scores of subjects in the remaining four political groups was computed to test this hypothesis.

The Sample

In attempting to determine what factors are associated with those students holding favorable attitudes toward nuclear science, an effort was made to elicit information from a representative cross-section of the student body at The University of Texas at Austin.

The sample was chosen to include students of different grade levels, subject majors, grade point averages, political leanings, and those who had received varying amounts of science instruction and who differed in their understanding of the principles and applications of nuclear science.

To reach such a representative group of subjects, arrangements were made with twenty-one different instructors in nine distinct academic departments of The University of Texas at Austin to collect data from their intact classes during regularly scheduled class periods. In this way data were obtained from over 1,200 students in twenty-five classes. Approximately 60% of these classes could be classified "introductory" or "of general interest" and were composed of students of widely varying backgrounds and interests. The other 40% of the classes were "upper division" or "more specialized" and were composed of more homogeneous groups of students.

Procedure

The experimental design of this study resembles in certain respects the Posttest-Only Control Group Design of Campbell and Stanley (1963) with the control group regarded as one of the N treatment groups. It should be noted that the numerical value of N varies according to which variable is being considered for statistical treatment e.g., five grade levels, fourteen groups of subject majors, four political groupings, etc.

The individual subjects were not randomly selected for participation in this study, but were included as a result of their instructor's agreeing to make class time available to the experimenter. Further, they were not assigned to specific treatment groups, but were considered to have already received the treatments under consideration by virtue of past experiences; that is, the number of science courses taken in high school and college, grade point averages achieved, understanding of nuclear science, etc.

Statistical Treatment of the Hypothesis

Hypothesis H_0 1: A correlation of .2566 was computed between the scores of 1,177 subjects on the ATRS and the TOUR Test. The procedure used was one suggested by McNemar (1969) for determining whether an obtained correlation coefficient deviates sufficiently from zero so that it cannot be regarded as a chance relationship from a condition of no relationship.

If N is greater than 100 and the correlation coefficient, r, is .50 or less, its standard error can be determined by:

$$\sigma_r = \frac{1}{\sqrt{N}} = \frac{1}{\sqrt{1177}} = \frac{1}{34.3}$$

When the obtained r is divided by this standard error, a Z-value is calculated which can then be entered in a normal probability table.

$$Z = \frac{r}{\sigma r} = \frac{.2566}{1/34.3} = (.2566)\ (34.3)$$
$$= 8.8 \text{ standard deviations}$$

The probability that this Z-value could have occurred by chance is less than .0001, hence Hypothesis H_0 1 was not accepted.

Hypothesis H_0 2: An analysis of variance among the mean ATRS scores of college freshmen, sophomores, juniors, seniors, and graduate students was computed and the results of this analysis are displayed in Table 1. Since the computed F-ratio of 3.308 indicates the ATRS scores achieved by those groups differ significantly at the .01 level, Hypothesis H_0 2 was not accepted.

TABLE 1

Significantly Different Mean Scores on the ATRS by Grade Level

(Any means underscored by the same line do not differ significantly at the .05 level.)

GRADE LEVEL	Freshman	Juniors	Sophomores	Seniors	Graduate Students
NUMBER OF SUBJECTS	228	349	306	289	31
MEAN ATRS SCORE	44.77	45.42	45.93	47.00	50.39

F–ratio=3.308
Significant at the .01 level.

Hypothesis H_0 3: An analysis of variance was computed among the mean scores on the ATRS attained by students who identified their grade point averages fell within fourteen subject-major groupings. The results of this analysis are displayed in Table 2. The computed F-ratio of 8.178 is significant beyond the .001 level, hence Hypothesis H_0 3 was not accepted.

Hypothesis H_0 4: When an analysis of variance was computed among the mean scores of the ATRS attained by students who identified their grade point averages as falling within five distinct ranges, a non-significant F-ratio of .330 was obtained. Hence, Hypothesis H_0 4 was accepted as stated above. The sources of this computation are reported in Table 3.

TABLE 3

Analysis of Mean ATRS Scores of Students With Different Grade Point Averages

G.P.A. RANGE	1.50-1.99	2.00-2.49	2.50-2.99	3.00-3.49	3.50-4.00
MEAN ATRS SCORES	44.26	45.90	46.17	45.83	45.98

SOURCE	MEAN SQUARE	D.F.	F-RATIO	P
Total	102.7643	1194		
Groups	33.9717	4	.330	.8586
Error	102.9956	1190		

TABLE 2

Significantly Different Mean Scores on the ATRS by Subject Major
(Any means underscored by the same line do not differ significantly at the .05 level)

SUBJECT MAJOR	Plan II	Home Eco.	Fine Arts	Comm. & Eng.	Soc. Sci.	For. Lang.	Hist. & Gov.	Educ.	Bio. Sci.	Geo.	Med.	Bus.	Eng. & Math	Phys. Sci.
NUMBER OF SUBJECTS	30	29	47	105	103	37	144	122	140	36	76	103	135	45
MEAN ATRS SCORES	39.17	41.31	42.26	42.34	43.20	45.41	45.69	45.81	46.10	46.64	48.12	48.71	49.46	53.42
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F-ratio=8.178, Significant beyond the .001 level.

Hypothesis H_0 5: An analysis of variance was computed among the mean scores on the ATRS of college students who reported having taken one, two, three, four, or more than four science courses in high school. The results of this analysis are displayed in Table 4. Because the obtained F-ratio of 11.365 is significant beyond the .001 level, Hypothesis H_0 5 was not accepted. Using Multiple Range Techniques, the ATRS scores of college students who had taken four or more science courses in high school were found to be significantly higher than those of other students.

TABLE 4

Significantly Different Mean Scores on the ATRS by the Number of Science Courses Taken in High School

(Any means underscored by the same line do not differ significantly at the .05 level.)

NUMBER OF HIGH SCHOOL SCIENCE COURSES	One	Two	Three	Four	More Than Four
NUMBER OF SUBJECTS	43	305	372	290	186
MEAN ATRS SCORES	41.74	43.86	45.30	48.18	48.05

F–ratio=11.365

Significant beyond the .001 level

Hypothesis H_0 6: A correlation of .1684 was computed between the scores of 1196 subjects on the ATRS and the midpoints of the ranges of semester hours they reported having studied in college science classes on the Student Descriptor Sheet. The procedure for converting correlation coefficients to Z-scores outlined by McNemar (1969) yielded the following results.

$$\text{standard error: } \sigma_r = \frac{1}{\sqrt{1196}} = \frac{1}{34.6}$$

$$Z = \frac{r}{\sigma r} = \frac{.1684}{1/34.6} = (.1684)\ (34.6)$$

$$= 5.83 \text{ standard deviation}$$

The probability that this Z-value could have occurred by chance is less than .001, hence Hypothesis H_0 6 was not accepted.

Hypothesis H_0 7: When an analysis of variance was computed among the mean ATRS scores attained by students who identified themselves politically as conservative, middle of the road, liberal, or radical left on the Student Descriptor Sheet, a highly significant F-ratio of 22.274 was obtained. The sources of this computation are reported in Table 5. Hypothesis H_0 7 was not accepted. Using Multiple Range Techniques for determining where significant differences lie among the means of unequal sized groups, it was found that the mean ATRS scores of each political group differed significantly from that of every other group at the .05 level.

TABLE 5

Analysis of Mean ATRS Scores of Students Expressing Different Political Leanings

POLITICAL LEANINGS	Radical Left	Liberal	Middle of the Road	Conservative
MEAN ATRS SCORES	38.60	44.88	46.52	49.63

SOURCE	MEAN SQUARE	D.F.	F-RATIO	P
Total	102.7714	1182		
Groups	2171.8897	3	22.274	< .0001
Error	97.5065	1179		

Conclusions

Of the seven hypothesis stated in null form that were tested in this study to determine what characteristics are associated with those college students holding the more favorable attitudes toward nuclear science, only H_0 4, expressing no relationship between a college student's grade point average and his attitude toward radioactivity, was accepted. Rejection of the other six hypotheses produced the following composite picture of college students who expressed more favorable attitudes toward nuclear science by their responses to the statements on the ATRS. They tend to be more knowledgeable about the principles and applications of nuclear science; they are likely majoring in a science-related subject; they have studied considerably more science in high school and college than college students who hold less favorable attitudes toward nuclear science; and they tend to be somewhat more conservative in their politics.

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THE DEVELOPMENT OF A CLASSROOM INTERACTION SYSTEM FOR SECONDARY SCIENCE STUDENT TEACHERS

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INTRODUCTION

This paper describes the development of an observation system specifically designed to provide feedback to student teachers about how they deal with the emotions and feelings of their students and how they deal with subject matter content processes.

The development of different goals of instruction in the science curriculum reform programs of the 1960's created new demands for teachers and their students. The emphasis on discovery and inquiry teaching involved ways-of-knowing such as experimenting, observing, predicting, inferring, and comparing. Classroom visitations by Pella (1967) and Tyler (1968) and the results of a study by Gallagher (1967) focused attention on the importance of helping teachers compare their teaching styles with those suggested by the designers of science curricula. Teacher education programs had to be modified to stress teacher behaviors consistent with the new methodological demands of the curricula. The need for providing prospective teachers with tools and skills that would encourage them to view the teaching process with a spirit of inquiry was reaffirmed, and an accumulation of empirical evidence supported the idea that interaction analysis systems were viable in helping teachers become aware of their verbal behaviors and teaching styles.

A survey of existing category systems which had been used in the training and supervision of student teachers indicated that most of them dealt with the emotional climate of the classroom and were "content-free." The cognitive systems reviewed were considered to be too complex to be useful as feedback devices and unsuitable for the identification of discovery and inquiry processes. The category systems developed for specific use in science classes were deemed unsuitable for providing a behavioral record sensitive enough to reflect subtle changes, yet simple enough to be analyzed and interpreted by student teachers with relatively few hours of instruction in the use of the system.

DEVELOPMENT OF THE INSTRUMENT

The use of a sign system for constructing the observation scheme was considered, but the idea of preserving some record of the sequence of behaviors using the Flanders matrix technique was found to be especially appealing and category approach was adopted. An analysis of many category systems revealed several common dimensions which were used to define specific categories of behaviors relating to the emotional climate in a classroom (Simon and Boyer, 1968). The systems usually included the teachers' reaction to pupils' ideas, feelings, attempts to set their own standards and working procedures, and behavior.

Systems relating to the processing of information included categories concerned with data recall, data processing, and evaluation as well as categories describing classroom talk about subject matter such as stating, explaining, interpreting, and inferring. A special attempt was made to define categories describing processes of science emphasized in inquiry-oriented science curricula. Considerable use was made of category systems developed by Parakh (1965), Balzer (1968), and Hall (1969) for use in science classes.

Audiotape recordings of science classes obtained from a data bank in the Science Education Center at The University of Texas were repeatedly played and used to identify specific types of verbal behaviors. Typescripts of lessons were made and tentative categories were formulated and used to encode additional tapes.

The selection of categories was influenced by the following guidelines: behaviors in both affective and cognitive domains were included; the processes of science were included; behaviors were of potential use for feedback to student teachers in terms of identifying strategies consistent with inquiry-oriented methodology; the primary emphasis was on *teacher* rather than student behaviors; categories were restricted to *verbal* behaviors, since it was hoped that teachers might wish to audiotape and analyze their teaching after the student teaching experience; the number of categories was limited to permit student teachers to learn the system with relatively few hours of instruction; and finally, each instance of observed behavior was classified into one and only one category.

After experimentation and revision, a final form of the system was developed. Several experimental formats were considered, but the Flanders organizational scheme described by Amidon and Flanders (1967) was eventually adopted because of its simplicity and adaptibility.

DESCRIPTION OF THE OBSERVATION SYSTEM

The observation system developed in this study was named *The Science Interaction System*. The categories were grouped into the three major divisions used by Flanders: Teacher Talk, Student Talk, and Silence or Confusion. The expansion of categories 3, 4, 5, and 6 into two, ten, ten, and three subcategories respectively, accounts for the sensitivity of the instrument in differentiating between teaching behaviors in science classrooms. The parallel design of categories 4 and 5 greatly simplified the learning of the system. The final form of the interaction system follows:

The Science Interaction System

TEACHER

1. Gives general support:
   Accepts feelings, praises or encourages, apologizes for error made earlier. Makes a humorous statement but not at the expense of a student.
2. Criticizes student conduct or rejects a student response:
   Reproaches a student or the class about conduct. Rejects a student response by word or intonation.
3. Accepts student ideas through:

R—*Repetition.*	Repeating student statements or thoughts. Paraphrasing a student's statement. Short response. "Yes," "Okay," "All right."
C—*Clarification.*	Building upon or developing student ideas by means of statements or questions usually directed to the student initiating the idea.

TEACHER

4. Asks for:		5. Gives:
F—*Facts.*	Information taken to be matters of fact. Reading, definitions (factual or operational), enumeration.	F—
E—*Explanations*	formulation of hypotheses, explanations by means of examples, opinions; interpretations of data.	E—
R—*Relationships,*	comparisons, contrasts, exceptions to the rule, classifications, numerical relationships involving the application of a formula or following a set of rules.	R—
P—*Predictions*	from data or concepts. Information thought to be a logical consequence of facts, conditions, or principles known or determinable.	P—
O—*Observations*	of a demonstration, a class experiment, or a diagram.	O—
X—*Experiments,*	plans to test hypotheses, suggestions for checking effects of changing variables in a demonstration, model, or proposed experiment.	X—
N—Information about the *Nature* of science. Information implying that knowledge is tentative. Nature of theories and facts. Distinctions between observations and inferences, theories and hypotheses.		N—
U—*Uses* of scientific principles. Explanations of everyday phenomena in terms of scientific principles involved.		U—
S—*Summary* or restatement of what has been said or what has happened during class or during previous classes.		S—
H—A *Hypothetical* situation. A proposed or imaginary situation.		H—

TEACHER

6. M—Facilitates *Managerial* procedures.	Makes announcements, assignments, gives directions.
R—*Recognizes* students.	Facilitates communication: Makes statements or asks questions which assist in the communication process. Repeats a statement or question which a student does not understand. Asks for a show of hands for a nose-count of a survey. Calls a student by name.
O—*Orients* in both content and procedures:	Sets stage by asking questions or making statements. Refers to what will be done or to what has been done or studied. Asks if students have had certain experiences. Justifies goals and selection of subject matter in terms of importance.

7. Makes *Irrelevant* statements: Makes statements not directly concerned with the class discussion.

STUDENT

8. Responds to a question asked by the teacher. Read[illegible]
9. Voluntarily makes a comment or asks a question. Ju[illegible]fies a previous answer. Gives an answer not expected. Gives his own ideas.

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10. Silence or Confusion: Silence for contemplation, observation of demonstrations. Multiple student interaction which cannot be understood by the coder.

OBSERVER RELIABILITY

Since *The Science Interaction System* was developed to give feedback to student teachers, the consistency with which independent coders were able to describe the same segment of classroom behaviors had to be determined. The author and a graduate student practiced coding behaviors from typescripts and audiotapes and developed ground rules as unusual categorization problems were encountered. Segments from randomly selected audiotapes from the data bank in the Science Education Center were coded and used to establish measures of observer agreement and coder stability using a coefficient proposed by Scott (1955). Coefficients of intercoder agreement ranged from 0.79 to 0.92 while measures of coder stability ranged from 0.77 to 0.91.

POTENTIAL USES OF THE SCIENCE INTERACTION SYSTEM

The category system developed in this study was primarily designed to provide a basis for specific feedback to student teachers in terms of how they deal with the emotions and feelings of their students and how they deal with subject matter content and processes. Teachers trained in the use of the system could study data derived from audiotapes of their classes and identify behaviors consistent with theories of learning and with inquiry-oriented science curricula. These teachers could be encouraged to modify their verbal behaviors, develop their own styles of teaching, and experiment with teaching strategies. Science supervisors could use data derived from audiotapes as a basis for supervisory conferences. Researchers could use the considerable descriptive power of derived data to investigate differences in affective and cognitive dimensions of teaching styles. Supervisors could investigate supervisory styles to determine if student teachers who initiate their own suggestions for changes in their behaviors change as successfully as student teachers who attempt to make changes based on supervisor-initiated suggestions.

SUMMARY

The purpose of this study was to develop an interaction analysis system designed to encourage science student teachers to modify their verbal behaviors.

A thirty-one category system was developed to code audiotapes of science classes and to generate data detailed enough to identify verbal behaviors, teaching styles, and teaching tactics consistent with theories of learning and with inquiry-oriented methodology.

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THE EVALUATION OF A VERBAL INTERACTION SYSTEM FOR SECONDARY SCIENCE STUDENT TEACHERS

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INTRODUCTION

The purpose of this study was to explore the effects of using an interaction analysis system developed by the writer to provide feedback to secondary science student teachers. The thirty-one category system used in this investigation, *The Science Interaction System*, was designed to help science student teachers identify verbal behaviors, teaching styles, and teaching tactics consistent with theories of learning and with inquiry-oriented methodology. The category system and the rationale for its development are described in another article in this monograph.

Relatively few studies involving the use of interaction analysis in the training of preservice secondary science teachers have been reported. Matthews (1966), McLeod (1966), Molchen (1967), and Yulo (1967) used "content-free" information from the Flanders System for feedback. This study differed from others in at least two important respects: (1) Feedback related to science content and the approach to content was provided through the development and use of a system specifically designed for that purpose. (2) Student teachers were trained intensively in the use of the system and were asked to analyze their behavioral records in great detail before each conference with their college supervisors.

The specific questions asked were:

(1) Do student teachers trained and supervised with *The Science Interaction System* (the experimental group) exhibit different verbal behaviors than student teachers not so trained (the comparison group)?

(2) Do student teachers in the experimental group change their verbal behaviors more than student teachers in the comparison group?

(3) Do student teachers in the experimental group change their attitude toward teaching more than student teachers in the comparison group?

The independent variable in this study was training and supervision with *The Science Interaction System*. The dependent variables were verbal behaviors as measured by *The Science Interaction System* and changes in attitude as measured by *The Teaching Situation Reaction Test* (Duncan and Hough, 1966). A pretest-posttest control group research design was used in the investigation (Campbell and Stanley, 1963). Audiotapes of each teacher in a normal classroom situation were used as bases for pre- and posttreatment measures of verbal behaviors. Scores on *The Teaching Situation Reaction Test* were used as pre- and posttreatment measures of attitude.

PROCEDURE

All student teachers in secondary school science enrolled at The University of Texas during the 1969 Fall Semester (N = 13) were randomly assigned to two college supervisors and to cooperating teachers. The students assigned to each supervisor were ranked according to their scores on Form E of the Rokeach Dogmatism Scale (Rokeach, 1960) since evidence gathered by Hough and Amidon (1964), Furst (1965) and Zahn (1967) indicated that this measure of "openness to change" was an important variable to control. The ranked students were then paired and randomly assigned to either the experimental or comparison group.

Student teachers in the experimental group received approximately nine hours of training in the use of *The Science Interaction System*. Performance objectives were developed and students were expected to demonstrate certain competencies by the end of the training period. Immediately following the training period, each student was audiotaped for feedback purposes. The tapes were analyzed by the writer using *The Science Interaction System*, and a computer program developed by Gouge and Hall (1970) was used to process the data and print matrices and ratios. Print-outs of each matrix were given to student teachers and their respective college supervisors within approximately four days of each taping. The student teachers were expected to analyze their print-outs according to the procedures set forth in a guide developed by the writer entitled *Interpreting the Matrix*. Each supervisor was trained in the use of the interaction system and was provided with an analysis of each print-out to be used as a basis for his conference with the student teacher. During the conference the supervisor and student teacher discussed the matrix and ratios, and the student teacher singled out a few specific behaviors which he intended to change in the next audiotape. This feedback and conference procedure was repeated two additional times before the postmeasures were made.

Student teachers in the comparison group were given a placebo treatment in an attempt to control the "Hawthorne effect." Approximately six hours of time were required for the introductory session and the completion of the requirements for this group. Each student teacher listened to four audiotapes of his classes at various times during the semester using *The Science Rating Scale* as a guide and prepared the suggested *Factor Profile* on each tape. These materials were developed by the writer specifically as a placebo treatment. Each student in this group was taped three times in normal classroom situations as were the students in the experimental group, but the audiotapes did not provide the focal point for supervisory conferences. Student teachers were not required to make special preparation for their supervisory conferences, and the college supervisors operated in their "natural" manner.

Analysis of variance was used to statistically treat group data for eighteen variables, and The Scott Coefficient of Agreement was used as a measure of intercoder reliability and coder stability (Scott, 1955). Coefficients of intercoder agreement ranged from 0.79 to 0.92 while measures of coder stability ranged from 0.77 to 0.91.

Results

At the end of the student teaching experience, students trained and supervised with *The Science Interaction System* differed significantly from student

TABLE 1

Analysis of Variance of Posttreatment Means

Variable	Group	Post Means	F	P^a
1. Expression of general support	Exp. Comp.	1.250 1.023	0.324	.292
2. Acceptance and clarification of student ideas	Exp. Comp.	12.657 9.829	3.509	.043*
3. Extended clarification of student ideas	Exp. Comp.	0.449 0.136	2.827	.059
4. Extended acceptance of student ideas	Exp. Comp.	0.831 0.669	0.455	.260
5. Student talk	Exp. Comp.	26.861 20.284	5.049	.022*
6. Student-initiated student talk (100)	Exp. Comp.	49.233 44.257	0.221	.326
7. Total teacher talk	Exp. Comp.	60.627 65.056	0.982	.328
8. Teacher factual talk	Exp. Comp.	14.301 21.630	7.031	.011*
9. The proportion of total teacher talk that is factual (100)	Exp. Comp.	57.093 75.326	8.778	.006**
10. Silence and confusion	Exp. Comp.	12.511 14.660	0.438	.528^b
11. Indirect-Direct ratio	Exp. Comp.	0.371 0.294	2.233	.080
12. Revised Indirect-Direct ratio	Exp. Comp.	0.500 0.397	5.291	.020*
13. Student Talk-Teacher Talk ratio	Exp. Comp.	0.464 0.317	4.180	.032*
14. Extended Teacher Talk-Total Teacher Talk ratio	Exp. Comp.	0.270 0.350	5.517	.019*
15. The number of question categories used	Exp. Comp.	4.857 4.333	0.871	.313
16. The number of talk categories used	Exp. Comp.	7.000 5.750	3.612	.041*
17. Cognitive flexibility ratio (100)	Exp. Comp.	11.964 10.397	1.495	.123
18. Flexibility ratio (100)	Exp. Comp.	16.709 15.548	0.743	.293

[a] Using a one-tailed test *< .05 **< .01

[b] Using a two-tailed test

teachers not so trained on eight of eighteen variables. It is not probable that eight of eighteen significant differences at the stated probability level could have occurred by chance. In addition, all of the differences in verbal behaviors were in the predicted direction. The results of the statistical analyses of the proposed hypotheses are presented in Table 1. Students in the experimental group differed significantly from students in the comparison group in the following respects: they built upon and developed student ideas more and placed a greater emphasis on the use of supportive and accepting behaviors in comparison to directing behaviors; they elicited more student talk in their classes; they gave less factual information when they talked; a greater proportion of teacher lecturing was at higher cognitive levels; they talked less in comparison to their students; they lectured less; and they were more variable in their approach to content in that they used more talk categories. The observed differences between the groups could not be attributed to the effects of extraneous variables such as history, maturation, and testing effects because of the nature of the experimental design. Since the groups were randomly assigned, selection should not be an explanation for group differences. Complete data were obtained for all subjects, thus mortality problems were nonexistent. The results were consistent with most of the findings of Furst (1955) and Zahn (1967), but inconsistent with some of the findings of Moskowitz (1965) and Yulo (1967). It should be noted that the methodologies of these investigators varied rather widely and comparisons are probably hazardous.

During the student teaching experience, students in the experimental group changed significantly more than students in the comparison group on six of eighteen variables, and all but two changes were in the predicted direction. There appeared to be a logical explanation for the two exceptions. The results of the statistical analysis of the proposed hypotheses are presented in Table 2. Students trained and supervised with *The Science Interaction System* changed significantly more than students not so trained in the following respects: they had a greater increase in building upon and developing student ideas; they had a greater decrease in their use of silence or multiple student interaction which could not be understood by the coder; they had a greater increase in their emphasis on supportive and accepting behaviors in comparison to directing and controlling behaviors; they had a greater increase in the variability of their approach to content; and they had a greater increase in the variability of their approach to teaching. The differences between the changes for the groups could not be attributed to confounding variables because of the experimental design.

Student teachers in the experimental group did not change their attitude toward teaching significantly more than student teachers in the comparison group. The results of the statistical analysis of the scores on The Teaching Situation Reaction Test (TSRT) are presented in Table 3. The results were inconsistent with those of Furst (1965) and Zahn (1967) who suggested that changes in attitude toward teaching as measured by the TSRT might be a prerequisite for actual changes in teaching behavior.

Several limitations of the study should be noted. Classroom performances could have been influenced by many factors which were not controlled, such as topics

TABLE 2

Analysis of Variance of Pre- and Posttreatment Means and the Difference Between Change Scores for the Groups

Variable[c]		Pre Means	Post Means	F	P[a]	Mean Changes	F	P[a]
1.	Exp.	0.704	1.250	3.360	.050*	0.550	1.015	.169
	Comp.	1.036	1.023	0.001	.489	− 0.013		
2.	Exp.	7.467	12.657	11.187	.003**	5.190	1.531	.120
	Comp.	7.005	9.830	5.470	.020*	2.824		
3.	Exp.	0.131	0.449	3.236	.047*	0.318	0.507	.013*
	Comp.	0.126	0.136	0.019	.445	− 0.100		
4.	Exp.	0.279	0.831	8.462	.006**	0.552	0.069	.400
	Comp.	0.184	0.669	6.816	.013*	0.485		
5.	Exp.	19.673	26.861	6.925	.011*	7.188	0.358	.284
	Comp.	15.532	20.284	4.429	.030*	4.752		
6.	Exp.	57.750	49.233	0.485	.253	− 8.517	0.062	.402
	Comp.	55.763	44.257	1.312	.279	− 11.506		
7.	Exp.	58.621	60.627	0.207	.330	2.006	2.375	.075
	Comp.	70.008	65.056	0.976	.326	− 4.952		
8.	Exp.	17.894	14.301	0.605	.543	− 3.593	0.105	.375
	Comp.	26.493	21.630	1.133	.157	− 4.863		
9.	Exp.	63.574	57.093	0.452	.260	− 6.481	1.247	.145
	Comp.	73.864	75.326	0.039	.421	1.462		
10.	Exp.	21.706	12.511	15.015	.003^{**b}	− 9.195	16.160	.002^{**b}
	Comp.	14.461	14.660	0.002	.962	0.200		
11.	Exp.	0.259	0.371	4.438	.027*	0.112	0.853	.311
	Comp.	0.225	0.294	3.926	.037*	0.069		
12.	Exp.	0.300	0.500	32.588	.000**	0.200	3.693	.039*
	Comp.	0.303	0.397	4.682	.027*	0.096		
13.	Exp.	0.366	0.464	1.878	.097	0.093	0.060	.403
	Comp.	0.240	0.317	2.904	.058	0.077		
14.	Exp.	0.354	0.270	4.222	.030*	− 0.084	0.057	.405
	Comp.	0.423	0.350	3.388	.050*	− 0.073		

[a] Using a one-tailed test $^{*}< .05$ $^{**}< .01$

[b] Using a two-tailed test

[c] See Table 1 for descriptions of the variables.

TABLE 2

Analysis of Variance of Pre- and Posttreatment Means
and the Difference Between Change Scores
for the Groups

Variable	Group	Pre Means	Post Means	F	P[a]	Mean Changes	F	P[a]
15.	Exp.	4.214	4.857	1.976	.092	0.643	0.652	.279
	Comp.	4.250	4.333	0.015	.450	0.833		
16.	Exp.	5.786	7.000	2.535	.067	1.214	12.472	.003**
	Comp.	7.000	5.750	3.947	.026*	– 1.250		
17.	Exp.	8.197	11.964	8.413	.007**	3.767	15.353	.019*
	Comp.	9.732	10.397	0.221	.326	0.665		
18.	Exp.	12.688	16.709	8.363	.007**	4.021	5.025	.022*
	Comp.	14.013	15.548	1.021	.169	1.535		

[a] Using a one-tailed test *< .05 **< .01

[b] Using a two-tailed test

which were taught, materials which were used, objectives for the lessons, and the operating procedures of the cooperating teachers. The operating styles of the college supervisors could also have had some impact on the reported outcomes.

Statistical treatment of group results to some extent masked the nature of the detailed feedback which students received about the manner in which they handled science content. This investigation was designed to provide individual feedback to student teachers in a manner which encouraged them to experiment with their behaviors. Data from the logs of supervisory conferences indicated that student teachers were successful in changing some of the behaviors which they committed themselves to change. Student teachers made 13 of 20 desired changes (65%) after Conference No. 1, 12 of 24 desired changes (50%) after Conference No. 2, and 19 of 24 desired changes (79%) after Conference No. 3. They were

TABLE 3

Analysis of Variance of Pre- and Posttreatment Means
and the Difference Between Change Scores
for the Groups

Variable	Group	Pre Means	Post Means	F	P[a]	Mean Changes	F	P[a]
TSRT	Exp.	202.000	202.000	0.000	.500	0.000	0.844	.310
Scores	Comp.	190.167	198.167	0.647	.278	8.000		

[a] Using a one-tailed test

unanimously enthusiastic about receiving interaction analysis data as a supplement to the feedback they received from their cooperating teachers and college supervisors.

The writer replicated this study at Louisiana State University, and although the data have not been statistically analyzed, the enthusiasm of the student teachers in the experimental group was impressive.

CONCLUSIONS

Training and supervision with *The Science Interaction System* appeared to have a significant effect on some of the verbal behaviors and changes in verbal behaviors of student teachers but had no effect on changes in their attitude toward teaching as measured by *The Teaching Situation Reaction Test*. Training secondary science student teachers in the use of techniques for analyzing their own behaviors seems to be a feasible way of encouraging them to experiment with teaching stategies. The finding that student teachers in the experimental group became significantly more variable in their approach to content and to teaching than student teachers in the comparison group seems to indicate that training and supervision with *The Science Interaction System* encouraged science student teachers to develop their own styles of teaching and to increase their individuality. The writer believes that this approach to working with student teachers is a viable one.

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A COMPARISON OF THE VERBAL BEHAVIORS OF PRE-SERVICE SCIENCE TEACHERS WHEN TEACHING SECONDARY STUDENTS AND WHEN TEACHING PEERS

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INTRODUCTION

The use of videotape feedback has been an integral part of the pre-service preparation of teachers for quite some time (Cyphert and Andrews, 1967). When using videotape or audiotape in microteaching situations, the user is generally faced with the decision of using either peers or the appropriate elementary or secondary students as learners. Steinbach and Butts (1969) found that those teaching elementary children asked questions more frequently, used teacher classification categories more frequently, and were more indirect than those teaching peers. Whether or not these differences would exist if pre-service teachers were teaching secondary rather than elementary students is not obvious.

Aubertine (1964), Olivero (1964), Steinbach (1969), and others have verified the importance of feedback in modifying teacher behavior. However, the validity and usefulness of videotape feedback when teaching peers should be limited by the degree to which teaching behavior when teaching peers is comparable to that when teaching students.

Johnson and Pancrazio (1971) found that it seemed easier to obtain desired training effects through peer teaching, but these effects do not seem to transfer to student teaching. While there were statistically significant differences between pre-service teachers teaching peers and those teaching secondary social studies students, the magnitude of the difference did not seem to be educationally significant.

In many microteaching situations, it is impractical to use classroom students; thus, peer teaching is the only viable alternative. If feedback is to be provided then the validity and usefulness of the feedback is, in part, dependent on the degree to which the teaching behavior before peers is comparable to the behavior that will be manifested in the classroom.

One instrument which has had wide utility in research and in teacher education is the Flanders (1963) Ten Catagory Interaction Analysis System. This system is basically an analysis of the quantity of time a teacher spends on various verbal behaviors.

THE STUDY

The problem considered in this study was, "In what ways is microteaching with peers a valid reflection of the verbal behavior which would be exhibited when teaching secondary school science students?" There are two aspects of verbal behavior which could be useful for feedback purposes: the quantity of time spent on various verbal behaviors and the quality or nature of certain categories of verbal behaviors.

Nine students were enrolled in both student teaching and a secondary science methods course. Each student teacher was asked to plan a twenty minute teaching sequence to introduce new content by means of a demonstration. In addition, the demonstration was to provide the students being taught with some experiences in using one or more inquiry skills. The twenty minutes for each tape was chosen because it represents the approximate maximum length of time in typical microteaching experiences.

Each student teacher was taped while teaching this lesson to a group of approximately sixteen peers. They were also taped while teaching this same lesson to a high school science class. The instrument used to analyze the tapes with regard to the quantity of time engaged to various categories of verbal behavior was the Flanders Ten Catagory Analysis System. The Scott coefficient measuring coder agreement between three coders was 0.879.

In order to determine the consistency of verbal behavior with respect to the percent of the total time spent in various categories when teaching peers and when teaching secondary students a correlation coefficient was calculated.

In an attempt to analyze the consistency with respect to the quality or nature of the verbal interactions occurring the author devised a simple modification of the Flanders instrument called the "Quality of Interaction Instrument." This instrument was designed to examine only three catagories of indirect behavior: praising, accepting, and questioning levels. Time available and budget restrictions for coders prevented a more extensive analysis. It was believed, however, that this limited analysis would allow a reasonable answer to the problem which would be useful for the purpose of giving direction to a more extensive study.

Table 1 describes the criteria used in analyzing the indirect behavior catagories. A simple scale from one to three was used as an indicator of the nature or quality of each indirect behavior.

TABLE 1

Appraisal for the Quality of Indirect Behavior

Category 2—Praise	
1 . . .	okay, all right, good, right, repeat student responses (mechanical, without much expression or conveying enthusiasm).
2 . . .	good, right, repeat answer (with feeling or enthusiasm that conveys teacher is pleased with the answer).
3 . . .	Very good, excellent, great idea (much enthusiasm).
Category 3—Acceptance	
1 . . .	okay, repeat answer (accepts answer but does not indicate that answer was right).
2 . . .	rephrases answer (indication that answer is acceptable but not necessarily correct or expected).
3 . . .	expands answer, asks class opinion, refers to student by name in later discussion.

Category 4–Questions
1 . . . recall, factual.
2 . . . higher, closed (specific applications, includes observations, convergent questions).
3 . . . higher, open (opinions, evaluation, divergent questions).

RESULTS

Table 2 presents the results of correlating the percent of time spent in various catagories of verbal behavior when teaching peers and when teaching secondary students. It can be seen from the correlation coefficients that the percent of time spent in praising, accepting, and questioning catagories varied for individuals from the situation when teaching peers to the situation when teaching secondary students. The fact that the correlation coefficients were not significant indicates that the percent of time spent in the catagories by individuals changed for the individuals but not in any consistent fashion. The percent of the total time spent lecturing and giving directions was fairly consistent for the two situations. The percent of time spent criticizing and in teacher talk varied for individuals. The I/D and i/d ratios also varied for individuals between the two situations.

TABLE 2

Correlations of Verbal Behavior
Peers vs. Secondary Students

Catagories	Correlation Coefficient
Use of Praise	0.36
Accepting Ideas	0.35
Asking Questions	0.23
Lecturing	0.61*
Giving Directions	0.78*
Criticism	0.26
Total Teacher Talk	0.34
I/D Ratio	0.16
i/d Ratio	0.16

* Significant at the 0.05 level

The results of the analysis of the quality of praising, accepting, and questioning as measured by the Quality of Interaction Instrument is presented in Table 3. The fact that all three correlations were significant indicates that the verbal behavior of the pre-service teachers when teaching peers closely paralleled their verbal behavior when teaching secondary students. The results of the t-test, however, suggests that the quality of the indirect verbal behavior of the pre-service teachers was consistently lower when teaching secondary students than when teaching peers.

TABLE 3

Quality of Indirect Behavior Exhibited

Category	Peer	Student	r	t
2	1.64	1.38	.69**	2.173*
3	1.60	1.43	.65**	3.131**
4	2.20	2.03	.74**	3.365**

* Significant at the 0.05 level
** Significant at the 0.01 level

CONCLUSIONS

The verbal behavior of individual pre-service teachers when teaching peers differs from that when teaching secondary students with respect to the percent of time spent praising, accepting ideas, criticizing, and in total amount of teacher talk. The percent of time spent lecturing and giving directions is fairly consistent for individuals in both situations.

The degree of indirectness as indicated by the I/D and i/d ratios varies for individuals when teaching peers and when teaching secondary students.

The quality of indirect behavior including praising, accepting, and questioning levels is consistently at a higher level when teaching peers than when teaching secondary students.

IMPLICATIONS

The results from this study indicate that feedback based on microteaching with peers may not be as useful as feedback based on observations of a pre-service teacher teaching secondary students. This is particularly true if the data accumulated for feedback purposes is dependent on a quantitative instrument such as Flanders Interaction Analysis System. Instruments attempting to identify the quality or nature of the interactions would appear to show more promise for this purpose.

While this pilot study was limited in scope it does suggest some areas for further study. Further research is needed to more clearly identify which of those behaviors exhibited when teaching peers will manifest themselves when teaching in the classroom. Until such time as these behaviors are identified, mircoteaching with peers may serve a function in helping students develop skills, but one cannot have confidence that the demonstrated skills will be transferred to the secondary classroom by the pre-service teacher.

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THE RELATIONSHIP BETWEEN TEACHERS' USE OF PUPILS' NAMES AND THE FREQUENCY OF CONFUSION IN THE SCIENCE CLASSROOM

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Discipline, classroom control, survival skills, or whatever else one wishes to call it, constitutes a major concern of student teachers who, traditionally, maintain less than adequate control of their classes during their first teaching experience. Despite the central location of classroom control in the spectrum of teacher concerns, there is little in the literature which would be helpful in structuring meaningful activities for training student teachers in this area. Alshuler and Shea (1974) describe the available literature quite aptly:

> What was there fell largely into the category of "Don't smile until Christmas," "Never turn your back on a class," "Get the troublemakers out of class quickly." We did locate and read reports on behavior modification teachniques for establishing classroom control, but these procedures seemed unjust in their unilateral application.

Even if the techniques outlined in that literature were necessary and effective, convincing the pre-service teachers who have been raised on Holt, Herndon, and Humanism to accept them before undergoing a painful experience in the classroom would rank somewhere along a seven-point Likert type scale between "difficult" and "nearly impossible."

So an important question is: What can student teachers do to maintain classroom control that they normally do not do, and that, at the same time, does not demean or otherwise detract from the self-concept of their pupils? A hint of an answer was heard when one of the authors listened to many hours of audiotaped lessons taught by student teachers. Those student teachers who seemed to have an inordinate amount of difficulty controlling their classes seemed to seldom address their pupils individually by name; when they addressed comments, statements and questions at all, they tended to address that amorphous many-headed beast known by such assorted titles as "class," "people," "everybody," and "ya'll."[1]

Below are reported the details of a study which supports this original guess, possible explanations of discrepant data, implications for pre-service teacher education, and some suggestions for future research.

[1] "Ya'll" would, of course, not be a nation-wide finding. Student teachers in non-Southern areas would likely be more prone to use "You" or "You guys."

PROCEDURE

One ten-minute sample of audiotaped classroom teaching of each subject was analyzed using a modification of the Flanders Interaction Analysis System in which category 10 – silence or confusion – was split into a category for silence and a different category for confusion. In addition to using the Flanders categories, an "N" was placed by the appropriate category code number each time the teacher addressed an individual pupil by name or used a pupil's name in another way In this fashion, the frequency of use of pupils' names could be determined as well as an estimate of the manner in which names were used. With several of the audiotapes, it was obvious when the class was just beginning or was about to end. When this was the case, the five minutes at the beginning or at the end of the lesson were not sampled because of the tendency of pupils to be more disorganized and/or less attentive than they would be during the middle of the lesson. Otherwise, the ten-minute samples were randomly selected from audiotapes of lessons which exceeded ten minutes. Samples were timed with a stopwatch to insure that each was exactly ten minutes long.

Each investigator recoded five tapes and the two investigators mutually coded five tapes different from those recoded. Scott's Pi coefficient (1955) was used to calculate both inter- and intra- coder consistency. Intercoder consistency was 0.81 and intra-coder consistency was 0.83 and 0.91, respectively. The consistency of teacher behavior from one lesson to another was obviously not determined since only one lesson per teacher was analyzed, but a review by Rosenshine (1973) indicates that an assumption of consistency regarding the teachers' affective behaviors examined in this study is not badly in error. The same review concludes that "one or two observations (per teacher) are sufficient to obtain a trustworthy mean score for the *group*," even for the more variable cognitive teacher behaviors.

POPULATION

Samples were drawn from three different populations: secondary science pre-service teachers who did their student teaching in the Spring of 1974 (n = 18), secondary science pre-service teachers who did their student teaching in the Fall of 1974 (n = 12), and ninth grade physical science teachers whose classes had been audiotaped during a period from 1971 to 1973 in conjunction with a previous unrelated study (n = 15).

DEFINITIONS

Use of Names: The number of times a teacher addresses a pupil by name or uses a pupil's name in some other way during the randomly selected ten minutes of instruction.

Confusion: The number of periods of up to three seconds in duration during which the coder could not understand communication. Confusion was typically caused by several students talking simultaneously or making other noises. If listening to the tape made obvious the fact that the teacher was writing on the board, passing out papers, talking to an individual, etc., this fact was noted during the coding by starring, and the accompanying periods of confusion were deliberately omitted from the final frequency tally for purposes of data analysis.

Extended Confusion: Periods of confusion as defined above except longer in duration than three seconds.

HYPOTHESES

1. There will be no significant correlation between the number of times teachers in the total sample use pupils' names and the number of times confusion or extended confusion occurs.
2. There will be no significant correlation between the number of times in-service teachers use pupils' names and the number of times confusion or extended confusion occurs.
3. There will be no significant correlation between the number of times pre-service teachers use pupils' names and the number of times confusion or extended confusion occurs.
4. There will be no significant difference between in-service and pre-service teachers in the number of times pupils' names are called.
5. There will be no significant difference between in-service and pre-service teachers in the number of times confusion occurs.
6. There will be no significant difference between in-service and pre-service teachers in the number of times extended confusion occurs.
7. There will be no significant difference between the ten pre-service teachers who use names most frequently and the ten pre-service teachers who use names least frequently in the number of times confusion or extended confusion occur.

ANALYSIS OF THE DATA

1. The frequency of occurrence of names, confusion, and extended confusion in each ten-minute sample of teaching were used to calculate Pearson-product-moment correlation coefficients for pre-service and in-service teacher subgroups and for the entire group of teachers. These correlation coefficients were used to test hypotheses one through three.
2. To test hypotheses four through seven, the t-statistic was used to determine significant differences between the means of the appropriate groups and the appropriate variables.

   The 0.05 level of significance for a one-tailed test was predetermined as the level for rejection of the null hypotheses.

RESULTS

The appropriate statistics are listed in Tables 1-3.

Hypotheses one through three are rejected. There is a significant negative correlation between the use of pupils' names and both confusion and extended confusion for both pre- and in-service teachers and for the combined group of teachers.

TABLE 1

Correlation Coefficients–
Use of Names and Confusion or Extended Confusion

GROUP	d.f.	VARIABLE	r.	p.
pre-service teachers	29	confusion	−0.55	<0.01
		extended confusion	−0.56	<0.01
in-service teachers	14	confusion	−0.54	<0.05
		extended confusion	−0.60	<0.05
all teachers	44	confusion	−0.52	<0.01
		extended confusion	−0.54	<0.01

TABLE 2

Comparison of Pre- and In-Service Teachers on Use of
Names, Confusion, and Extended Confusion

GROUP	n	VARIABLE	MEAN	VARIANCE	d.f.	t.	p.
pre-service teachers	30	use of names	10.06	38.47	43	0.41	n.s.d.
in-service teachers	15		10.73	2.60			
pre-service teachers	30	confusion	10.60	219.83	43	1.97	0.05
in-service teachers	15		2.86	16.98			
pre-service teachers	30	extended confusion	2.93	15.51	43	2.00	0.05
in-service teachers	15		0.80	2.06			

Hypothesis four is accepted. Pre- and in-service teachers do not differ significantly in the number of times per ten minute period that they use pupils' names. Hypotheses five and six are both rejected. There is a significant difference between pre- and in-service teachers in the occurrence of both confusion and extended confusion, with in-service teachers experiencing much less confusion. Hypothesis seven is rejected. Student teachers who use names frequently have significantly fewer incidents of confusion per ten minute period than student teachers who do not use names frequently.

DISCUSSION

Inspection of the data shows that the assumption of homogeneity of variance has been severely strained if not shattered. In addition, the tapes of the group of

TABLE 3

Comparison of Pre-Service Teachers Who Do and Who Do Not Use Names Frequently

GROUP	n	VARIABLE	MEAN	VARIANCE	d.f.	t.	p.
frequent use of names	10	use of names	17.30	16.01			
infrequent use	10		3.30	3.12			
frequent	10	confusion	2.00	4.66	18	2.78	0.01
infrequent	10		18.10	330.76			
frequent	10	extended confusion	0.80	1.06	18	2.79	0.01
infrequent	10		5.20	24.17			

pre-service teachers who did their student teaching in the Spring of 1974 were among those which impelled the authors to conduct the study in the first place, thereby possibly biasing the study. Also, the in-service teachers were taped in conjunction with another study, and this study may have had an effect on the results of our study. The reader should bear these points in mind when considering the results and conclusions of the experiment.

After considering the results of the analyses the authors attempted again to uncover any research reports or essays related to teachers' use of pupils' names. The search was probably far from exhaustive but *Current Index to Journals in Education* and *Research in Education* (ERIC) were investigated completely and similar descriptors in *Education Index* were investigated back to 1960. The only paper uncovered in this search was an essay by Reis (1972/1973) in which he stressed the importance of using pupils' names and suggested some techniques which teachers could use for rapidly learning their pupils' names. He reviewed no research and did not list a bibliography of any sort.

The research reported above supports Reis' opinions concerning the importance of using pupils' names. Although other factors are likely involved, using pupils' names seems to be important in maintaining classroom control. Teachers who consistently use their pupils' names seem to experience less confusion than teachers who do not and, as a general rule, confusion in the class increases as the teachers' use of their pupils' names decreases. A closer examination of the manner in which names were used offers even more support than the correlations and comparisons of means.

For example, the difference in variability of the occurrence of confusion and of extended confusion between those pre-service teachers who used names frequently and those pre-service teachers who used names infrequently was quite puzzling. As a matter of course, the means for the Fall 1974 and the Spring 1974 groups were compared and these groups were not found to differ significantly from each other on any of the variables examined, allowing the assumption that the two samples were drawn from the same population, so we know that the difference in variability was not due to Fall vs. Spring student teaching. Upon examining the frequency tables listing use of names, confusion, and extended confusion for these two groups, we noticed three teachers in the infrequent group for whom confusion occurred much less frequently than for the other seven (in fact, two of these teachers experienced no confusion at all). This was puzzling so we looked at the interaction matrices for this group to see if there were any differences in the teaching patterns. Six of the seven teachers who were experiencing confusion were conducting or attempting to conduct discussions or inquiry teachings of some sort. The three who were not experiencing confusion and also not using their pupils' names were almost exclusively lecturing. This led us to examine the matrices for all the teachers to discover other interesting observations.

The variabiilty of occurrence of confusion was also quite high for the middle group of student teachers who were not in the groups analyzed for those who used pupils' names most or least frequently. Three of these teachers experienced confusion quite frequently and the other seven did not experience confusion as frequently. Examination of the matrices revealed two fairly distinct teaching patterns. For the seven student teachers who experienced confusion infrequently, the confusion would arise after the teacher asked a question and then failed to designate a respondent, resulting in several students offering different answers simultaneously. The teacher would then name a respondent or, taking advantage of non-verbal cues unavailable to audiotape coders, would repeat one of the answers or use some other tactic such as probing or redirecting to continue the lesson. When names were used, they were used most frequently to designate a desired respondent to one of the teacher's questions and less often to praise a pupil or to use a pupil's name with a contribution made to the discussion by that pupil. Two of the three teachers in this group who experienced confusion were lecturing, but unlike the lecturers in the infrequent name group, their pupils were obviously not attentive. Short spurts of confusion became periods of extended confusion until, finally, each of the two teachers began issuing orders to offending pupils by name and began criticizing individual pupils, again by name. The other student teacher in this group who was experiencing a great deal of confusion was attempting to conduct a discussion without using pupils' names. Again, as short spurts of confusion became periods of extended confusion, the teacher "cracked down," issuing orders and criticism by name.

Although the in-service teachers' lessons were much less variable than the student teachers' lessons, similar patterns were observed. One major difference was that the in-service teachers who used pupils' names with orders or criticism were much more likely than the student teachers to do so following the first or second spurt of confusion. Another difference between the student teachers and the in-service teachers was pacing. Although the in-service teachers as a group used names fewer times during a ten-minute period than the group of ten student teachers who used pupils' names most frequently, the in-service teachers generally used names about as frequently *per transaction* — that is, the pace of instruction was slower, and there were fewer teacher-pupil interactions per ten minutes of teaching. This may account for the difference in variability of confusion between student teachers even though the frequency of name usage per ten-minute period was about the same.

The results and observations discussed above are easily explained. In a very real sense, teaching is the selling of ideas and, as successful salesmen already know, using the names of their clients is crucially important. Children are no less self-centered than adults and their responding in predictable ways to the use, or lack of use, of their individual names should come as no surprise.

Teachers who consistently address their pupils as individuals, with individually different names, probably make their pupils each believe that the teacher feels he or she is an important person. When a teacher uses a pupil's name in asking a question, giving praise, or using a contribution, the pupil probably feels more important as an individual because he or she has contributed or is about to contribute to the lesson. On the other hand, if the teacher responds to a pupil as an individual only when giving orders or criticizing, the pupil probably believes that the teacher doesn't have much respect for him or her as a person. Pupils who feel disrespected by the teacher are likely to return the perceived disrespect and to cooperate less fully in the classroom.

IMPLICATIONS FOR PRE-SERVICE TEACHER EDUCATION

Even if the proposed explanation is incomplete or even incorrect, analysis of the data and the other less formal observations indicate that there is a fairly strong negative relationship between how and how often a teacher uses pupils' names and how often those pupils cause confusion to occur during a lesson taught by that teacher. Therefore, to help pre-service teachers avoid classroom confusion during their student teaching, teacher educators should arrange for pre-service teachers to encounter the opinion that using pupils' names is important and should give their pre-service teachers training in how to use pupils' names. This training could take the form suggested by Reis (1972/1973) or might take another form entirely.

Activities to aid pre-service teachers in learning their pupils' names at the beginning of the student teaching experience should also be used. The student teacher might check roll several times for the teacher before taking over the class. The pupils might be asked to sit in assigned seats for the first few days so that the student teacher could begin to associate names on a seating chart with faces at a certain location in the classroom. If a camera is available, the student teacher might take a photograph of the class, identify the pupils with the help of the cooperating teacher, and then use this photograph as an aid in memorizing the pupils' names.

Learning the names will, of course, hardly be sufficient. The student teachers discussed above who had to "crack down" on their obstreperous pupils, issuing both orders and criticism to several individuals by name, obviously knew the names of their pupils. Student teachers should, if at all possible, audiotape their teaching several times near the beginning of their student teaching experience. Then they and/or their supervisors can listen to their teaching to determine how often and in what ways they use pupils' names. They might discover, for example, that the pupils who cause trouble seldom are asked questions or praised by name.

Whatever pre-service teachers do and however they do it, the research reported in this study indicates that those pre-service teachers who, quite early in their student teaching experience, develop the habit of consistently using their pupils' names will have fewer problems with classroom control than student teachers who develop this habit later or not at all. Since it stands to reason that those student teachers who aren't forced to worry about classroom control can concentrate more on a wide variety of interactive behaviors than can those student teachers who are constantly battling their pupils, it also stands to reason that teacher educators can teach their pre-service teachers more about teaching during the student teaching experience if those pre-service teachers learn early to consistently use their pupils' names.

SUGGESTIONS FOR FUTURE RESEARCH

The first suggestion is for a careful replication of this study, preferably without the weaknesses mentioned above. Also, the correlation coefficients are a bit larger than we expected them to be and this may be partially due to experimenter bias since both the coders are aware of the nature of the study. Ideally, any replication should insure that the original observers or coders are not involved in the study except as data gatherers. Several teaching patterns relating to teachers' use of pupils' names were suggested from an examination of the interaction matrices. Any replication of the study should also determine whether these patterns are objectively real or are merely artifacts of the individual teachers recorded for this study.

We hypothesized that a teacher's use of a pupil's name in part determines that pupil's perception of his or her relationship with the teacher. A pupil's self concept might be affected in a similar manner. Using techniques similar to those above and one or more acceptable instruments for determining self concept and perception of pupil-teacher relationships, one could test this hypothesis. A similar study to test the relationship between teacher's use of a pupil's name and pupil achievement would also be interesting.

A facet of the name problem not investigated in this study is the question of how many different pupils a teacher consistently addresses by name. A teacher who consistently fails to call on twenty other pupils, and consistently calls on only five pupils in a class of twenty-five, has mastered only part of the technique. Research in another context reported by Adams and Biddle (1970) indicates that this may be a strong possibility. If this occurs, the effect on classroom control and/or the occurrence of confusion, pupil self-concept and perception of pupil-teacher relationships, and pupil achievement should be investigated.

Several suggestions were made with regards to teaching pre-service teachers to use their pupils' names during student teaching. These and other methods should be evaluated in ongoing teacher education programs to determine effective methods for teacher education in this area.

SUMMARY

The purpose of the study was to determine the relationship between the tendency of teachers to use their pupils' names and the tendency of teachers to have problems in maintaining control of their classes.

Randomly selected ten-minute segments of audiotaped lessons taught by thirty pre-service and fifteen in-service teachers were analyzed using a modification of the Flanders Interaction Analysis System to determine the frequency of the use of pupils' names and the frequency and duration of periods of confusion.

A significant negative correlation between teachers' use of pupils' names and the occurrence of both short and extended periods of confusion was observed. The frequency of occurrence of both short and extended periods of confusion was significantly greater in lessons taught by student teachers who used pupils' names infrequently. Both short and extended periods of confusion occurred a significantly larger number of times in lessons taught by pre-service teachers than in lessons taught by in-service teachers even though both pre- and in-service teachers tended to use pupils' names with approximately the same frequency.

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